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OUT of DOOR STUDIES IN GEOGRAPHY·

BY F. M. FULTZ

PART I.

Ice and Water Erosion

A Study of the
Upper Mississippi
Region

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OUT OF DOOR STUDIES IN GEOGRAPHY

I

THE MAKING OF THE SURFACE AND SOILS of the UPPER MISSISSIPPI REGION

BY
F. M. FULTZ
Superintendent of the Schools of
Burlington, Iowa.

1916
BLOOMINGTON, ILLINOIS
THE PUBLIC-SCHOOL PUBLISHING CO.

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By F. M. FULTZ

PREFACE.

The matter contained in this little book has been prepared with the thought of bringing within the grasp of grammar school pupils some knowledge of the origin of rocks and soils, and of the sculpturing of the earth's surface, which has usually been left for more advanced classes. The writer believes that knowledge concerning the facts presented should be much more common than it is.

As far as possible, difficult, scientific terms and phrases are avoided and those names employed which are in most common use. Definite localities are taken for study in order to intensify interest and furnish real types for comparison.

Acknowledgments are due to a number of persons for the loan of photographs. Proper credit is given with each illustration. However, I desire to express special obligations to Prof. W. W. Atwood, of the University of Chicago; Prof. C. W. Hall, of the University of Minnesota; Prof. Charles F. Curtiss and Prof. Samuel W. Beyer, of the Iowa State College of Agriculture and Mechanic Arts; Prof. Samuel Calvin, of the Iowa State University, and Prof. W. H. Norton, of Cornell College.

That so many of the illustrations are from my own photographs is due to my many years of interest and study in the general subject and to having been privileged to make extensive field observations.

Francis M. Fultz.

Burlington, Ia., June 1, 1908.

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GRANITE DOMES OF THE YOSEMITE.

Washington Dome on the left. Liberty Cap on the right. The Granite in these domes is *igneous*, or *unsedimentary* rock.

OUT OF DOOR STUDIES IN GEOGRAPHY.

INTRODUCTION.

Some Interesting Things About the Earth.

The study of the earth is a wonderfully interesting thing. What shaped the hills and valleys? How were the rocks made? Where did the soils come from?

It all took place so long ago and the forces of Nature work so slowly that men must study hard and think long and deeply to get at the secret. But when they have once thought it out and have told us about it, often it seems so easy and plain that we wonder someone had not found it out long ago. But it has frequently happened, too, that no one would believe them at first.

No one man ever studied it all out. It took many of them, following one after the other, and each profiting by what those before him had learned.

For instance, it was in this way that we have come to know so much about rocks. There was a time long ago when men did not know much about them. One man, who was studying them in his own country, said he thought they had been made by fire, and he told why. At first not many people believed him, but we now know he was largely right, and that the rocks he studied were once fused in a great heat and were molten. He called them *igneous* rocks, from the Latin *ignis,* meaning fire.

There was another man who was studying the rocks in another part of the world. He had read what the first man wrote about the rocks and couldn't agree with him. This second man said that the rocks he was studying looked as if they had been made by water. They were in layers like the mud that has been washed into a hole by water, and some of them even had ripple marks on them like the sandy beach of the sea. This man was right, too. The rocks he was studying were laid down in a shallow sea. When this second man wished to write about the rocks he was studying, he also used a Latin name and called them *aqueous,* from *aqua,* which means water.

A third man was studying the rocks. He read what the other two had written about them and said to himself: "I wonder if they can both be right? I will find out for myself." So he traveled around and examined the rocks in different parts of the world, and he found the *igneous* rocks and the *aqueous* rocks very easily, for the other men had described them very well indeed, and there were plenty of them to be found.

But this third man found out something else, too. He came across some rocks which looked very much as if they had been made by water; yet from the marks they bore he could see that at some time they had been in a very fierce fire. They were in layers like the *aqueous* rocks, but the material looked very different. This puzzled him for a while, but he thought long and very hard about it and finally thought it all out. Then he said: "These rocks were first made by water; then long afterwards fire took hold of them and entirely changed their character." He called them *metamorphic* rocks, from the Latin word *metamorphosis,* which means a changing.

It was discovered later that many of the igneous rocks, as well as many aqueous rocks, had become metamorphic rocks.

When the man who discovered that some rocks had been made by water, told about what he had found, scarcely anybody believed him. It wasn't so unreasonable to suppose that rocks could be made by fire, because many volcanoes were known which brought up molten material from somewhere within the earth. But how could rocks which were on the dry land and sometimes high up on the mountains be made by water? What had become of the water?

Then the man who discovered the aqueous rocks said something still more surprising. He said that the rocks had been made in the sea and then pushed up to become dry land. He found the shells and skeletons of salt-water animals in the rock, which proved the first part of his statement, that the rock had been made in the sea. To prove that it had been pushed up out of the sea was not so easy. But the more people thought about it, the more possible it seemed, and in the course of time everybody believed it.

We now know that not only have there been up and down movements of the earth's crust in the past, but that some are now actually going on. For instance, the coast of New Jersey is slowly sinking, the rate not being more than two feet in a century; and the coast of Norway is slowly rising.

What these men found out about the rocks has been of great use to the many who have since studied them and saved a great deal of trouble and hard work. Later students have continued to find out more and more about them, so that now, that which a few hundred years ago was a secret to everyone is common knowledge which anyone of us may know after a little study and work.

Nor do we know it all yet. The men who are studying the rocks now are learning new and interesting things all the time; things which have always existed, but which no one has ever before discovered.

For a long time, before men had yet learned so much about the earth, it puzzled them a great deal to know where the material came from, and what it was like, out of which fire and water made the rocks. But by long study and much thinking they found this out, too. They had a hard time making people believe them at first. But everybody who studies the subject at all now-a-days believes it.

This is what they found out:

Countless years ago the earth was like the sun, fiery hot and molten. After ages and ages of gradual cooling, an outer crust formed from the hardening of the molten material. This crust was at first very thin and was continually breaking up and forming again. This went on for age after age, and all the while the earth was cooling off and the mass becoming harder and firmer. The hard, firm material thus formed was *igneous* rock, or as we generally call it *unsedimentary* rock.

Although the unsedimentary rocks were all made from the same original material, yet there are many kinds of them, owing to the different conditions under which they cooled.

The *sedimentary rocks* (which they used to call *aqueous* rocks), have been mostly made from worked-over ma-

A LIMESTONE BLUFF ALONG THE MISSISSIPPI RIVER.
It is composed of *sedimentary* or *stratified* rock.

terial furnished by the rotting down and the wearing away of the unsedimentary rocks, and from the remains of the limestone-forming animals which lived in the sea. But more will be said about this further along in the book.

The agencies working to tear down the unsedimentary rocks were much more vigorous in the far past than they are at present. This is especially true of falling and running water. In the very early ages of the earth's existence the water must have been in a constant state of change. The heated surface of the earth would cause it to rise as vapor. The vapor rising to greater heights struck the colder air and was condensed to water, which fell in great floods. This process repeated over and over again, almost without end, must have caused rapid and enormous

GRAND CANYON OF THE COLORADO RIVER.

The walls of the lower, narrow part of the gorge are of igneous rock. This inner gorge is about 1500 feet deep.

The walls of the upper, wider part of the gorge are of sedimentary rock. These sedimentary rocks are over 4,000 feet thick.

erosion and produced much material for the making of sedimentary rocks.

While all rocks are classified under the three heads, *unsedimentary, sedimentary and metamorphic,* there are many different kinds of each one of these; so many, in fact, that it would be very difficult to learn to recognize them all. However, we should know one type, at least, of each. The following may be taken as the most common and widely distributed types:

GRANITE for the *unsedimentary,* or *igneous.*

LIMESTONE and SANDSTONE for the *sedimentary.*

MARBLE and QUARTZITE for the *metamorphic.*

Marble was made from limestone and quartzite from sandstone. Gneiss, (pronounced like *nice*), is another metamorphic rock. It was made from granite.

You should be able to recognize granite, limestone and sandstone. They are not difficult to learn. It would also be well for you to know marble and quartzite. With a very little practice you could do so. Gneiss varies a great deal and is more difficult to recognize.

There are many rocks which resemble true granite, and it is often difficult for anyone but an expert to distinguish them. They are commonly called granitic rocks.

It was long after men had begun studying the rocks that they learned anything about glaciers. A hundred years ago people thought that a glacier was simply a great mass of ice lying in a deep mountain valley. When those who made a study of the subject said that a glacier had a regular movement much like that of a river, very few persons believed them. So much interest was aroused by the statement, that many men of science took to studying glaciers; and they were easily convinced that the great masses of ice were really streams of ice.

But they soon discovered something more, something so startling that when they told about it, people everywhere, even many learned men, said: "Now surely these men of science are crazy." What they discovered was, that not only did ice move down a valley in the mountains, but that some time long ago it had moved out of the valleys on to the plains, in some places for great distances. No wonder people didn't believe them. By this time many had come to think that ice might possibly move down a mountain side. But to expect them to believe that it moved out on a level plain! That was asking too much!

But many went to see for themselves. And when they saw what the men of science had described, they knew it was true. It was such an interesting thing that men in many parts of the world took to studying it, and it was soon learned that immense areas, both mountains and plains, had once been covered with glaciers.

There are many other things that men have discovered in their study of the earth. But those I have just told you are the things which have to do particularly with what appears in this book.

ICY BAY, ALASKA.

This picture was taken about five or six miles from Muir Glacier, which shows in the distance. The whole bay is full of floating ice, broken from the front of the glacier.

I.

GLACIERS.

Glaciers have had so much to do in shaping the earth's surface that knowledge about them should be much more common than it is. At some time in the distant past most of the northern half of the north temperate zone was covered with ice, and in some places it extended even farther southward. There were extensive ice-fields, too, in the southern hemisphere, but as there is very little land in the south half of the south temperate zone, or further south, they must have been mostly on the sea.

Glaciers have played a wonderful part in preparing the surface of the earth to support living things. As we shall find out later, they have done much to make the north central part of the United States the remarkably fertile region it is. It is wonderful, too, to think how Nature's forces were working so long ago, and in such strange and powerful ways, in order that the earth today might be richer and more beautiful.

When we look out over the prairies of Iowa, Illinois and other northern states, and see the fine farms, the grassy hillslopes and the timbered valleys, it is hard for us to think that once there was a great mass of ice covering the whole region. When we think of glaciers, we somehow or other always connect them with mountains. We have probably gotten this idea because the pictures we see of glaciers are mostly of those in mountain valleys, and because these mountain valley glaciers are more easily visited than the great fields of ice which are still found in the polar regions.

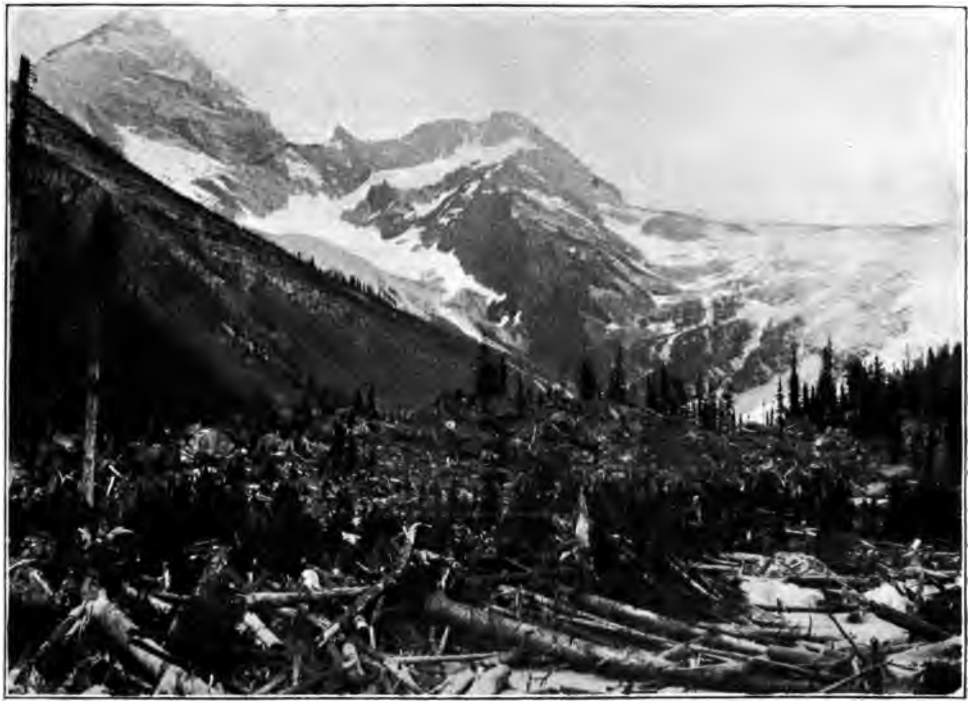
The mountain glaciers, too, are more easily studied than the great ice-fields; therefore men like Agassiz, who have tried to find out all they could about ice movements, have spent their time in the mountains where glaciers still fill the valleys. And if you and I wish to visit a glacier and see for ourselves how the mass of ice is formed and how it acts, we, too, should first go to a small one somewhere in the mountains, where we could take in all the surroundings in one view, and where we could walk around and over and under the glacier itself. What we learned there would help us to understand more easily how the great ice masses move, such as once covered so much of our country, or as still exist on the lands near the poles.

Of course the reason we find the glaciers in the mountains is because of the snow which falls there. In the lower valleys and on the plains the moisture falls in the form of rain. When we look at the hard, pure ice of a glacier, it is difficult for us to realize that it has been made from white, fleecy snowflakes. Yet such is the case.

Where snow piles up to a great depth, the lower part becomes packed from the weight of that above. As the mass becomes thicker and heavier, it begins to shove outward. Of course on the mountains it moves more quickly, because it can move downward as well as outward. This moving packs it closer together and it becomes firmer and harder, just as you find the dry white snow acts, out of which you are trying to make a snowball some cold day in the winter. If you keep at it long enough you will get a snowball. It takes many years for the white snow on the mountain top to become the hard, blue glacier ice in the valley below. In some of the glaciers of Switzerland it takes more than a hundred years for the snow which falls on the mountain top to appear at the foot in the valley below.

As the snow moves down from the mountain top it naturally crowds into the valleys. This crowding continually breaks it up and packs it again. This hastens the change that is gradually taking place. The snow which was soft and fleecy at the top, becomes close and compact a little farther down and there are no separate snowflakes; a little farther down still it is granular and icy; away below it is hard, firm ice.

To understand a thing best you should see it for yourself. The next best thing you can do is to see pictures of it and hear someone tell about it who has seen it. Many of you cannot see glaciers and study their movements. So I am going to show you some pictures of several of them and tell you what you might see if you visited them, as I have done.



ILLICILLIWAET GLACIER, Canada, on the extreme right.

The ridge of bowlders and rock-waste across the foreground was a terminal moraine when the front of the glacier was half a mile further down the valley than at present.

SOME AMERICAN GLACIERS.

ILLICILLIWAET GLACIER, CANADA—THE ALPINE TYPE.

Anyone who has made a journey over the Canadian Pacific Railway from the great prairies of Manitoba to the Pacific Coast has marvelled at the rugged scenery and been lost in admiration of the majestic mould of the face of the earth in that region. Everywhere mountains rise with snow-crowned tops into the clouds, and everywhere great gashes pierce the ridges, and mountain streams rush and dash and lash themselves into foam in their headlong haste down the steep slopes.

Looking out of the car window, one sees here and there, on a level with the railway track, even in the months of July and August, great patches of snow, and farther back the spread of glaciers coming down the valleys from the mountain tops. Many of these glaciers are within easy reach, and in a day's journey may be explored by anyone who is at all familiar with mountain climbing.

Perhaps the nearest of all, and the most easily reached, is the Illicilliwaet Glacier, which lies less than two miles south of the railway, and to which there is easy access from the station of Glacier. The approach is up a narrow valley which the glacier itself has ground out in the ages gone. From the passing train the front of the ice sheet seems not more than an half mile away, and as one looks up the valley and on up the glacier itself, it seems as if one could reach it in a five-minute walk; but when one starts up the valley the trip is not so quickly made, although there is a good path and the ascent is not so very rapid. The five-minute walk stretches out into a half-hour walk; but everywhere on the way there is something of interest, something new, so the trip is one of pleasure and does not seem at all long.

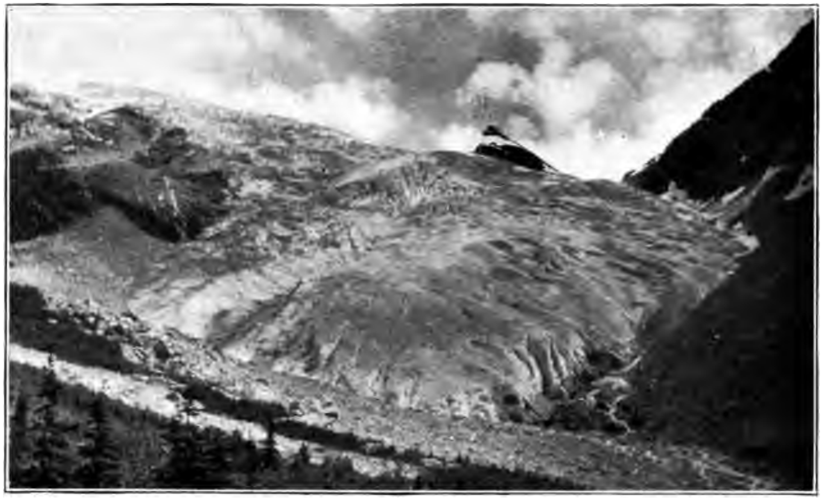
The valley is narrow, the sides rising abruptly to mountain peaks, some of which are 10,000 feet above the sea. Everywhere, high up on the sides of the valley and on the peaks, there are patches of snow. Directly back from the front, the glacier rises up and blends with the snow field, which in turn, seems to blend with the sky. During the winter the valley is filled with snow; but in July there is a mass of luxuriant vegetation which extends even moderately close up to the front of the glacier. The pines and firs which have found a foothold along the sides of the valley in crevices of the rocks, and here and there on the floor of the valley, show the effects of the great mass of snow which has covered them during the winter. Their boughs point downward, this position having been forced by the great weight of the snow during the long winter months. There are beautiful ferns everywhere, and even the rocks that are not constantly subjected to the wear of the torrent are covered with moss.

Following the pathway leading to the foot of the glacier, we cross the Illicilliwaet river a number of times. It is a rushing, roaring torrent, already quite a river, although only a mile from the place of its birth. For it owes its being to the melting ice above. The path winds in and out among the great boulders that the glacier has wrenched from the mountain sides and carried down into the valley. These boulders show the rough treatment they received on the way. They are covered with scratches, and many of them have flat surfaces, showing how they have been held in the strong, firm grasp of the ice while they were dragged over the rocky bed. The stream itself is choked with the huge rocks, ground and scarred by the glacier and rounded and smoothed by the torrent. Between the boulders are lodged trunks of trees which have been torn from the mountain side by avalanches of snow.

The path goes up over an old moraine, a great ridge of material lying across the valley, showing where the glacier, halting at one time and for a considerable period, piled up the rock waste brought down in its course. The boulders in this moraine are not so water-worn as those that lie in the torrent itself, but show plainly the scratches and ground surfaces gotten in their rough journey on the glacier.

As we proceed on up the valley, the trees grow fewer and smaller, and soon there is nothing but mere brushwood, which itself soon ends abruptly. Then there is a bare strip of cobble stones and boulders a few hundred feet wide before the glacier is reached. This bare strip of cobble stones represents the winter advance and summer retreat of the glacier. For during the winter months the valley and whole region is covered with a deep blanket of snow, and the constant waste of the ice is less than the constant advance, although the rate of movement is but a few inches per day. So in the late spring, when the snow in the valley is gone, and the glacier is again exposed, the ice-front is found to be considerably farther down the valley than when the snow covered it in the fall. During the summer the waste is much greater than the advance, and the front of the glacier again retreats up the valley.

Crossing this bare strip, the ice-

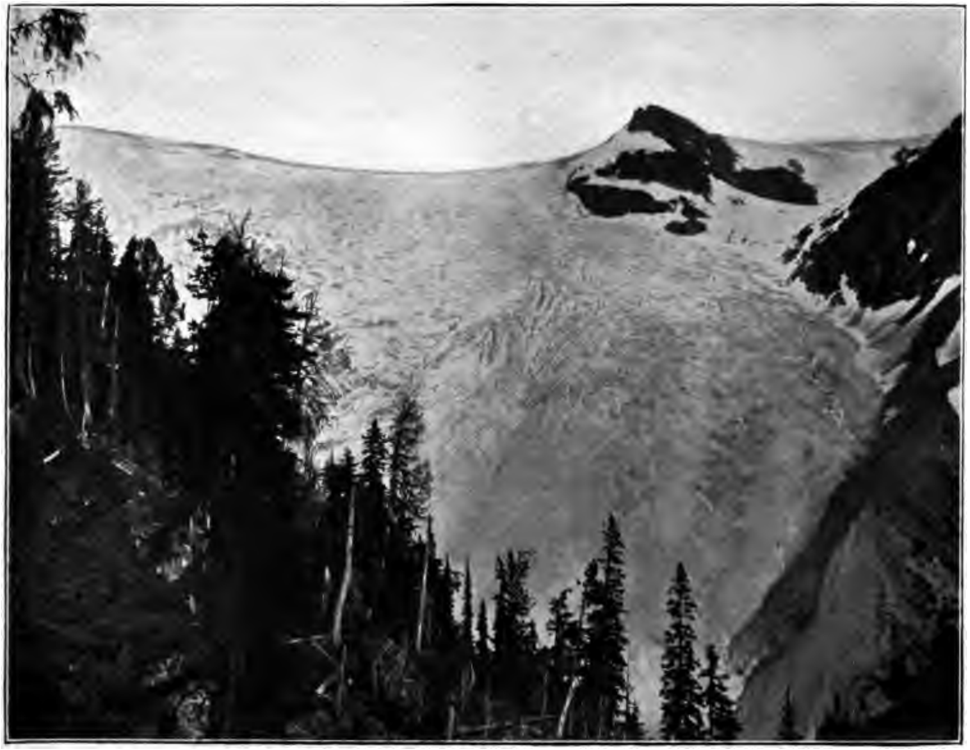


THE FRONT OF ILLICILLIWAET GLACIER.

The front rests on a bed of bowlders. There is no true terminal moraine at present on account of the glacier being slowly on the retreat up the valley. That is, the summer retreat is a little greater each time than the winter advance.

front is reached. The ice is found to be resting on the bare rocks, the bed resembling that of the bare strip just crossed. Melting is going on, for it is July, and the rocks everywhere are wet from the dripping water. Here and there the water collects into little streams; and at the lowest point a large stream is flowing out from a cave which extends back under the ice-front. We go back into this cave and find ourselves surrounded by hard blue walls of ice; for the ice of the glacier is of indigo color. This cave does not extend back any great distance, and one does not care to remain within very long, because the temperature is near the freezing point.

Coming out of the cave and looking up the face of the glacier, we see the surface a dirty and uninviting white from the weathering of the ice and the fine dust that has settled there. We wish to climb up on the glacier, and find it so steep that it is necessary to cut steps, and to go carefully even then. If we wish to go far up, we send a guide ahead to cut the steps,



LOOKING DOWN INTO THE FACE OF ILLICILLIWAET GLACIER.

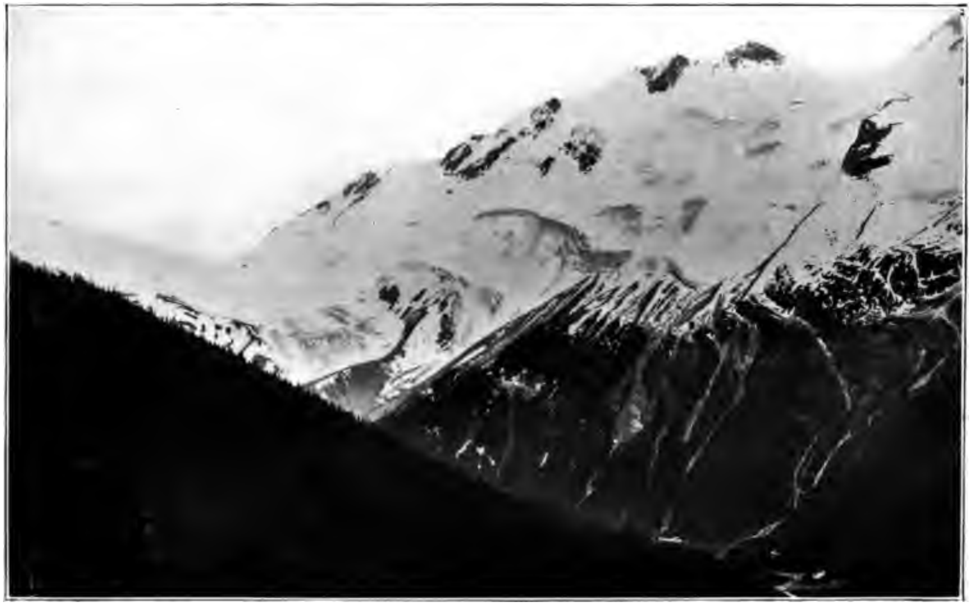
This view was taken from a point over 2,000 feet above the floor of the valley at the foot of the glacier. Notice the ridge-like lateral moraine on the right. During the winter the glacier must move up nearly to the top of this moraine. The region of coarse snow, or nève, shows in this picture.

and follow after him. A rope connects us all so that should anyone slip the others will sustain him. This method of getting up on the glacier is exciting, but not so easy as climbing one of the mountain ridges alongside of the glacier until we are far up on one of its flanks, and then working out onto its face.

The snow fields from which comes the snow that makes this glacier are extensive and extend back many miles.

Up here the snow falls, or is likely to fall, nearly every day of the year; and the marvellous whiteness of the field is in striking contrast to the dirty surface of the glacier.

In crossing from one of the bordering ridges to the surface of the glacier, one must be careful, as the piles of debris are made up of fine material which may prove as dangerous as quick-sand. These side moraines extend on either side down past the front of the glacier, where they are piled up very much after the fashion of the roof of a house. In some of the glaciers in this region these side moraines extend almost continuously around and nearly unite in front of the glacier, leaving only a small opening through which the glacial torrent finds an escape.



ASULKAN GLACIER, CANADA

This is a hanging glacier. Notice how high up on the side of the valley it is. Also the many streams and cascades coming down from it.

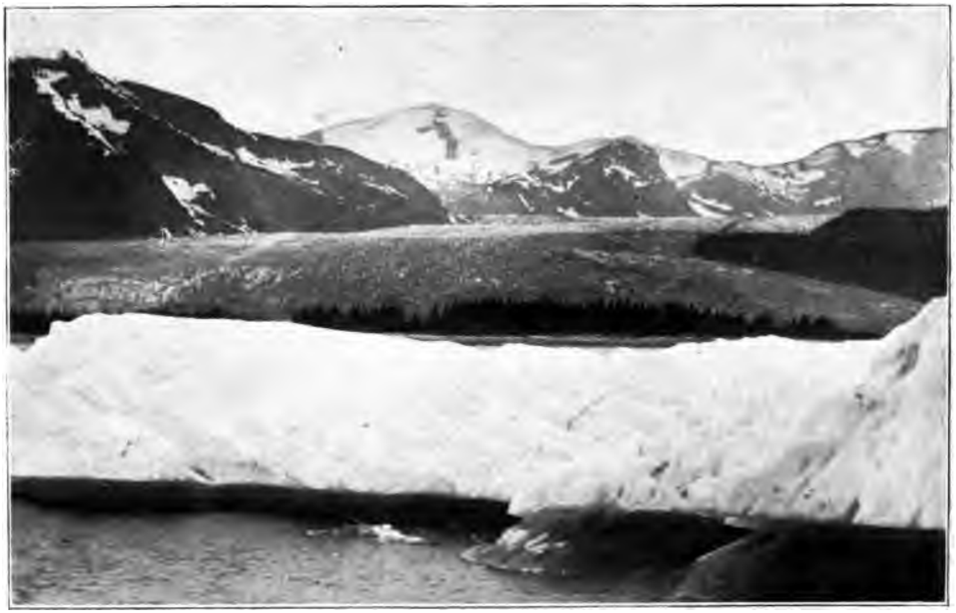
Glaciers of this type are called *Alpine* Glaciers because they abound in the Alps, and were first studied there.

There are many Alpine glaciers around Mts. Ranier, Baker, Hood, Shasta and other high peaks of the northwestern United States; also quite generally throughout the Canadian Rockies.

The valley through which the stream from the Illicilliwaet Glacier flows away has two forks, one contains the Illicilliwaet Glacier, just described, while the other is circled by several hanging glaciers. One of these hanging glaciers is the Asulkan, which lies in a trough parallel to the valley and high up on one of its sides. There is no true front to this glacier, but from many places along its lower edge issue streams which cascade down the valley side, and make it seem like one stretch of broken water-falls for nearly two miles.

NORRIS GLACIER, ALASKA—RESEMBLING THE PIEDMONT TYPE.

The farther northward we go, the lower down the valleys come the glaciers. Sailing along the coast of British Columbia and southeastern Alaska, ranges of mountains are everywhere visible whose ridges are eternally snow-covered. Leading down from the perpetual snow-field, every valley has its glaciers. Many reach only a short distance and, seen from the distance, look like mere tongues of snow projecting from the general field. Others fill the valleys for a considerable distance, only to melt away as the warmer and lower level is reached, and to send a rushing torrent down to the sea. Some fully emerge from their steep troughs, push out toward the channel along which we are sailing, and spread out fan-like over the great mass of debris and rock waste that the glacier in time past has torn relentlessly from the mountain sides and carried down to the sea. There the front lies like the segment of a great circle, separated from the sea only by a half-mile-wide fringe of forest-covered moraine. Should you climb up over this moraine and pass on to the glacier, you might not



NORRIS GLACIER, ON TAKU INLET, ALASKA

This glacier partakes somewhat of the Piedmont type. The front is more than a mile in width. Notice the spreading out of the ice when it escapes from the narrow confines of the valley. Notice, also, the forest covered moraine that stretches across the entire front between the glacier and the sea. The ice-berg in the foreground came from Taku Glacier, several miles further up the inlet. This picture was taken from the deck of a steamer while passing the glacier.

know where the moraine stops and the glacier begins, because the forefront of the ice is pushed out beneath the great mass of rock waste. Such an example is the Davidson Glacier on Lynn Canal, or the Norris Glacier on Taku Inlet.

While the Davidson and Norris glaciers are not true piedmont glaciers, (*pied-mont* means *at the foot of the mountain*), yet they have many features of the piedmont type. A true piedmont glacier is one where two or more main glaciers flow into a common basin and unite to form a *lake* of ice. The lake of ice is the piedmont glacier.

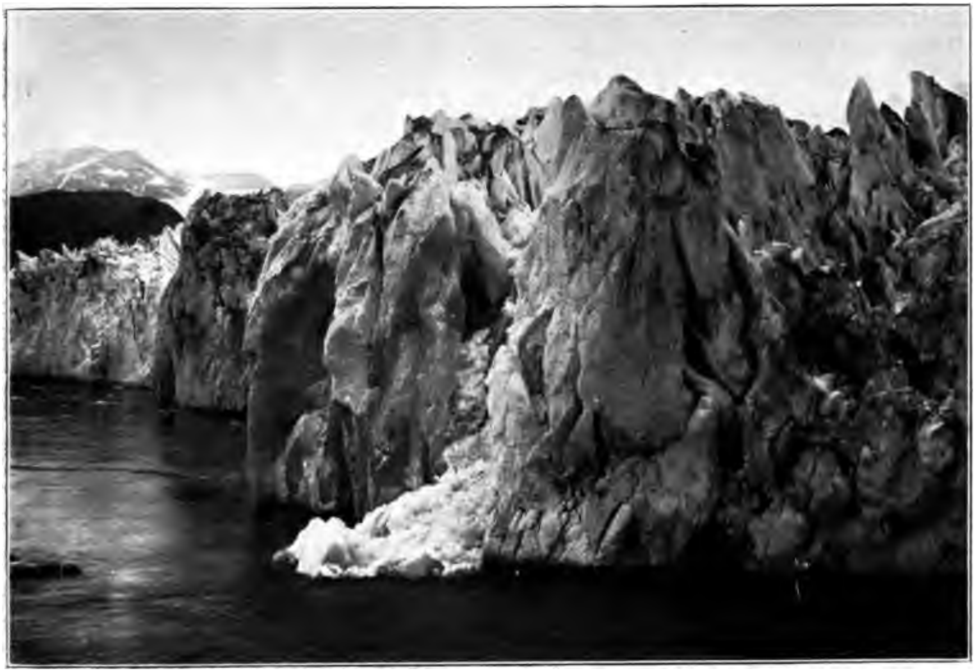
The ice in the lower part of the Norris Glacier acts very much like that in a true piedmont glacier. While the tributaries all unite with the glacier above the point where its valley widens out enough for the ice to spread to any extent, yet for some distance at the lower end, the valley does widen out, and there the ice acts very much like that in a true piedmont glacier. The forward movement slows up and the ice spreads out to three or four times its width above.

Such a glacier gives one a good understanding of the great mobility of large masses of ice. When the ice-stream is confined within a narrow, canyon-like valley it is frequently as deep as it is wide; but as soon as it escapes its prison walls it spreads out like tar or some other thick, viscous substance, until its width is many times its depth. This spreading out hastens the melting, and only the larger glaciers flow for any great distance beyond where they leave their confining valley walls. It results, too, in the rock-waste being more widely distributed.

TAKU GLACIER, ALASKA

This is a tide-water glacier, discharging ice-bergs directly into the sea. The front is about half a mile wide and the ice-wall in front about 100 ft. high. Compare the valley of this glacier with that of the Norris Glacier.

The volume of ice in the Norris Glacier is so great that, if it had not been allowed to spread out at the lower end, but had been confined within narrow walls until it reached the sea, icebergs would be continually breaking away from it. This is what happens to Taku Glacier a few miles farther up the bay.



FRONT VIEW OF MUIR GLACIER

This wall of ice is about one and a half miles long and from 250 to 300 feet high. Ice-bergs are contiually breaking away from it. Soundings have shown the water at the deepest place in front to be 600 feet deep. Note the fissures forming, showing where masses are preparing to break away.

THE MUIR GLACIER, ALASKA—TIDE-WATER TYPE.

But there are still other glaciers that push fully out into the channel and from which great masses of ice are constantly breaking away, and choking the channel that leads up to the front with huge floating blocks.

One of the greater and more impressive glaciers of the tide-water type is Muir Glacier, situated about one hundred and fifty miles northeast of Sitka. It was named from its discoverer, John Muir, who explored it in 1879.

The approach of Muir Glacier is up

Icy Bay. Twenty, or even thirty miles away from the glacier, one finds the channel filled with the floating ice; and ten miles away it is so blocked that careful navigation is required to make the passage. Icy Bay is a long narrow channel once the bed of Muir Glacier when it extended far beyond its present limit. The bare rocky sides of the channel show the marks of the old ice sheet that ground along the course and a few rocky islands rise in the midst of the channel, rounded and scored by the same agency when they were covered to the depth of a thousand feet or more.

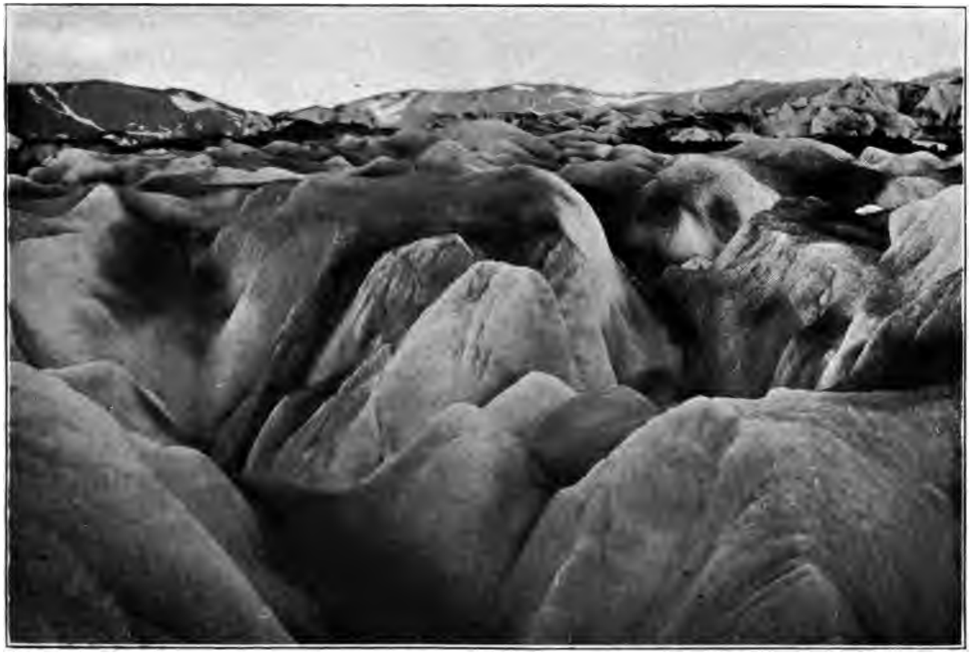
Long before the front of the glacier appears in sight, rumblings like the distant booming of cannon are heard. They continue to grow louder as the glacier is approached and are found to come from the forming of crevasses and the breaking away of great masses from the front.

A half mile or more away from the front the steamship comes to anchor, surrounded by icebergs and continually rising and falling with the swells sent out by the constant plunging of ice masses from the front of the glacier.

The front of Muir Glacier rises from 250 to 300 feet above the water and extends down beneath the surface to a distance of nearly 600 feet, as shown by soundings taken directly in front. Huge masses are continually breaking away from the front, leaving the hard blue glacier ice constantly exposed. Great crevasses show in the perpendicular face, indicating where masses will soon separate from the glacier and plunge into the sea to become ice-bergs. On either side of the valley the glacier pushes out on the mass of material accumulated from the lateral moraines.

Climbing the sides of the valley at some distance in front of the glacier and working along the flanks of the mountain, one can go out onto the top. Care must be taken however, as the soil over which one travels is frequently but the covering of a great mass of ice, which beneath is slowly melting away, leaving caverns into which the rock waste above drops when its weight becomes too great for the arch beneath to sustain.

Looking across the glacier towards the northwest, no limit to the ice field is seen until the horizon shuts out the

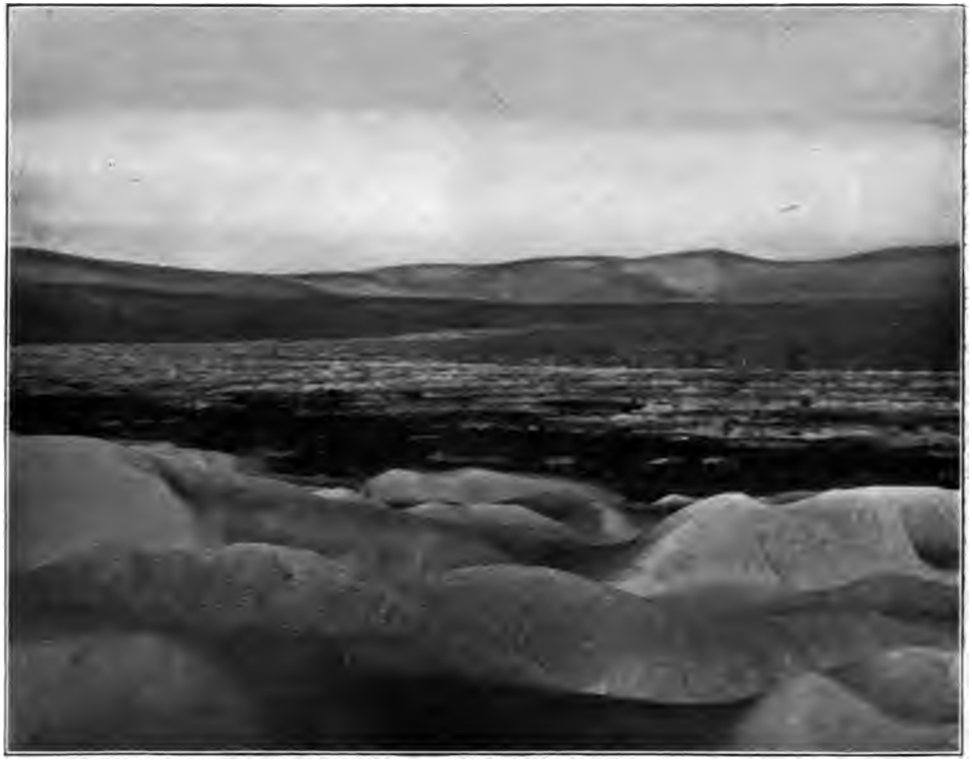


TOP OF MUIR GLACIER

Notice the uneven surface and the lines of rock-waste showing where the medial moraines are. Also the crack at the bottom of the depression at the left of the center; this was once an open crevasse.

view. In other directions the mountains rise at varying distances of from ten to fifteen miles. Down the valleys of these mountains come small tributary glaciers that feed the great lake of ice which lies in the basin-like valley, very much as rivers of water supply a lake of water.

Seen during the summer, the top of the glacier is dirty and unattractive, for the snows of winter have melted and the dust and fine rock debris lie scattered over the entire surface. Here and there lines of larger rock waste, which mark the medial moraines, are seen winding along through the field of ice and indicating where the main flow is, somewhat after the



TOP OF MUIR GLACIER; VIEW LOOKING NORTH

Notice the stream-like movement, the medial moraines, the surrounding mountains and the tributary glaciers. The ice in the foreground is about motionless, and is backed up by a mountain of rock which stands just to the left of the picture and which is completely surrounded by the ice-field.

manner of the lines of drift-wood in the spring floods of rivers.

Passage over this field of ice is exceedingly difficult. Open crevasses meet one, completely barring the way, or compelling one to make a long detour. These crevasses are frequently of apparently endless depth. Tumbling a boulder into one of these yawning abysses, it goes rumbling down and down until lost to both sight and hearing. Again one comes to a lake, the water of the same deep blue as the glacier ice. This lake will probably be occupying a valley in the ice caused by one of the old crevasses which has closed below and yet yawns above.

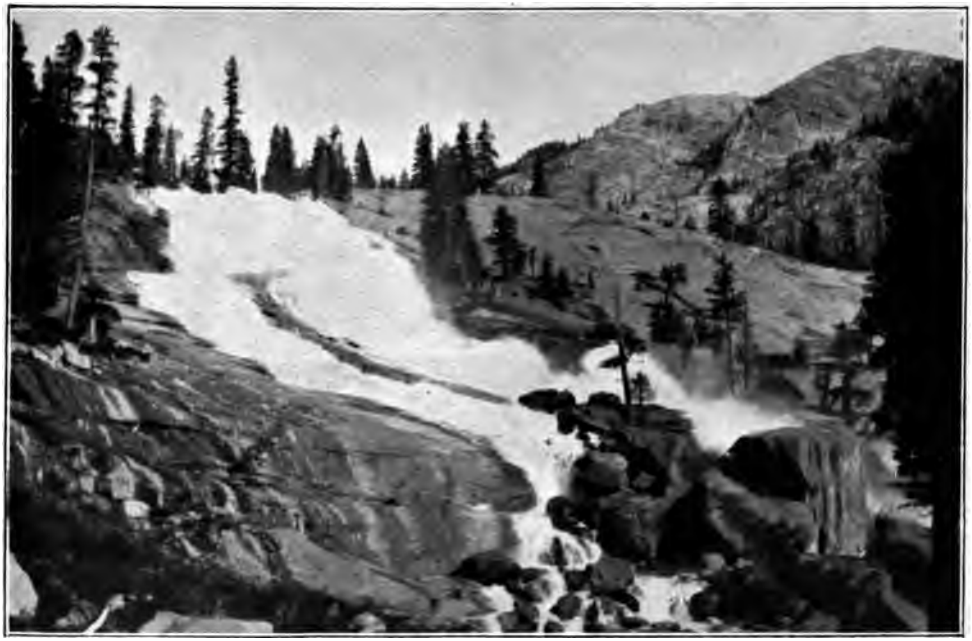
Standing on one of the moraines out in this ice field one might think it the solid land, so great is the amount of waste and so profuse the rock material; but dig down through the debris a few feet, sometimes only a few inches, and the solid glacier ice appears.

One can also pass beneath this great glacier for a short distance, for, out in front, on either side of the gorge, there is a sand beach running up to the very front of the glacier which is uncovered at low tide. Following up this beach, one can go in beneath the glacier, where a glacial stream emerges, to a distance of several hundred feet. Here, standing on the sand, one finds oneself surrounded above and on the sides by hard blue walls that are freezing cold and tries to realize what it means to have a solid roof of ice above one 300 feet thick.

There are many tide-water glaciers throughout Alaska and in other parts of the world. Farther north along the Alaskan coast there are glaciers much larger than Muir Glacier.

Greenland is practically covered with one great ice sheet many times the thickness of the greatest Alaskan glaciers. This great body of ice moves out from the center toward the coast in all directions. Around the south and southwest coast, the waste of the ice sheet is so great that it is only occasionally that the front reaches tidewater; but on the northwest and north and northeast coasts the ice wall almost everywhere reaches the sea, and the great icebergs are sent out which crowd the North Atlantic and which, in some seasons of the year, make navigation dangerous.

The south pole is surrounded for many hundred miles with a continuous ice front several hundred feet high, from which icebergs are continually breaking away.



LOWER CALIFORNIA FALLS OF THE TUOLUMNE RIVER, CALIFORNIA.

This picture calls forth exclamations rather than interrogations. It is evident that a heavy moving glacier once filled this region, rising much higher than the mountain walls. They have been rounded and the bare rock polished the same as the floor of the valley. No soil is in sight, yet the trees find root-hold in the crevices. It is a question whether the tree roots do not do more than the water in breaking up the granite floor. The river channel is but a few feet in depth, though the water has been running for thousands of years.

II.

ICE AND WATER EROSION.

The most vivid illustration of ice and water erosion is found in canyon-formation.

Some canyons have been ground out by glaciers. Others, and by far the larger number, have been cut out by streams. There are many, too, that were first ground down by a glacier and afterward cut still deeper by a stream. Then there are some that were first started by a stream, afterwards ground down by a glacier, and now again are occupied by a stream. From the condition and shape of the walls it is usually easy to tell what the glacier has done and what the later stream has done.

There was a time thousands of years ago when glaciers covered a much larger part of the earth than they do now. In the United States they extended in some places down past the middle of the North Temperate zone. The Rocky mountains, Sierra Nevada, Cascade, and other western ranges were covered with glaciers, and many of their canyons and gorges were ground deep at that time. After the glaciers melted away, rivers took their places and continued the work of canyon-making. But the rock-cutting of ice is different from that of water, and it is easy to tell where the former left off and the latter began.

The glacier-ground canyon has smooth walls. Where the rock is hard and compact, it is often highly polished, or contains scratches and grooves made by angular rocks dragged over it by the ice. It is usually straighter, and there are no sharp angles at the turns. This happens because the ice-stream is of considerable depth, filling up its channel and causing long-continued erosion at the sides. Then, too, ice does not move around an angle as readily as water, and the wear on anything that obstructs its course is heavy and constant. The walls are thus ground down so smoothly that after the glacier is gone, they resist water erosion and do not quickly become rough and uneven with jagged, projecting rocks and deep gulches. The floor of the canyon will be broadly rounded or nearly flat; never V-shaped. And it is not likely to have any perpendicular drops; but there may be many sharp inclines where the falls of the glacier were. If the glacier overflowed the sides of its channel, as often happened, the rim of the canyon will be rounded.

Where a glacier-made canyon opens out on a plain, there are frequently high embankments extending from the mouth on both sides, sometimes for several miles, producing in this way a continuation of the valley. These are lateral moraines, and are made of the material ground and torn from the sides of the canyon. Such extensions of lateral moraines are found only where there is a very great amount of this material. Frequently all of the morainic material is blended in a fan-shaped deposit at the mouth of the canyon, bordered with a continuous ridge, excepting where the glacial stream has kept an opening for itself. One thing is noticeable at the mouth of a glacier-made canyon; much of the material is only carried a short distance. Of course the glacial stream takes up the fine mud which is ground from the rock bed, and carries it away even to the ocean; but all the coarse and heavy material carried on the top and along the sides of a glacier is dumped at the first opportunity.

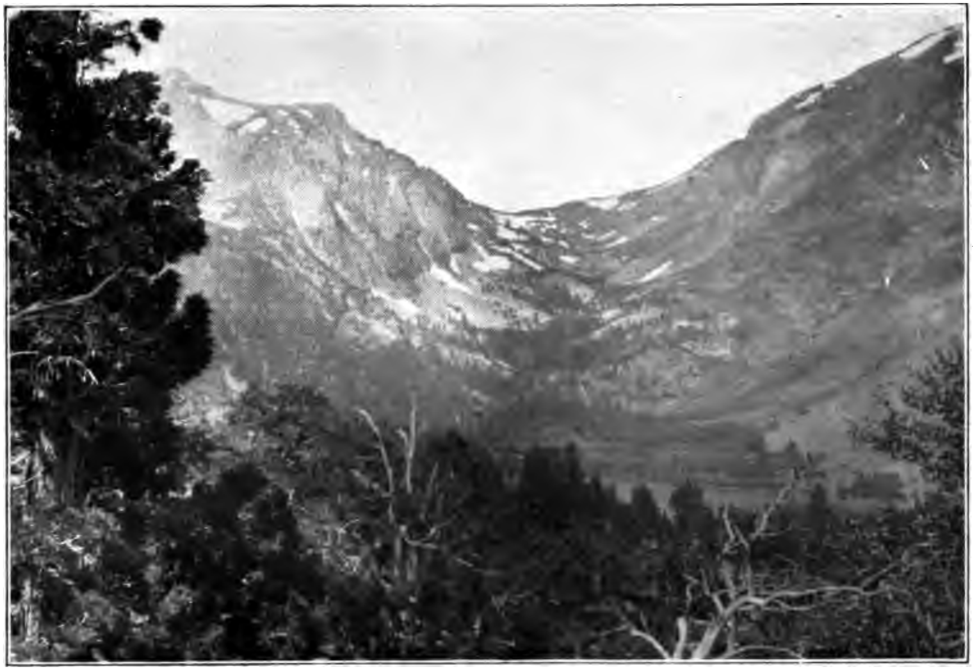
Whenever the front of the glacier has remained stationary for any length of time, there is a terminal moraine. It is not unusual to find a number of these in one canyon, scattered along at intervals, each representing a rest period in the retreat of the glacier. Often they act as dams, holding behind them beautiful lakes.

Bowlders are another characteristic of a glacier-made canyon. They are found sometimes lodged on ledges along the sides; often on the floor of the valley; anywhere, in fact, where the glacier in its retreat has left them.

BLOODY CANYON, SIERRA NEVADA MOUNTAINS.

Bloody Canyon on the east side of the Sierra Nevada, near Mono lake, is a good type of the glacier-ground canyon. It is nearly straight and only a few miles long, so that it can be viewed as a whole from a single point. The descent is 3,000 feet in about 4 miles, showing that the movement of the ice must have been very rapid, and the grinding and scoring vigorous. This is easily believed when one sees the immense mass of morainic material piled up at the lower end.

In viewing the canyon from some distance below, one notes its wide, rounded appearance. The rounding of the rims has much to do in producing this effect. When standing within

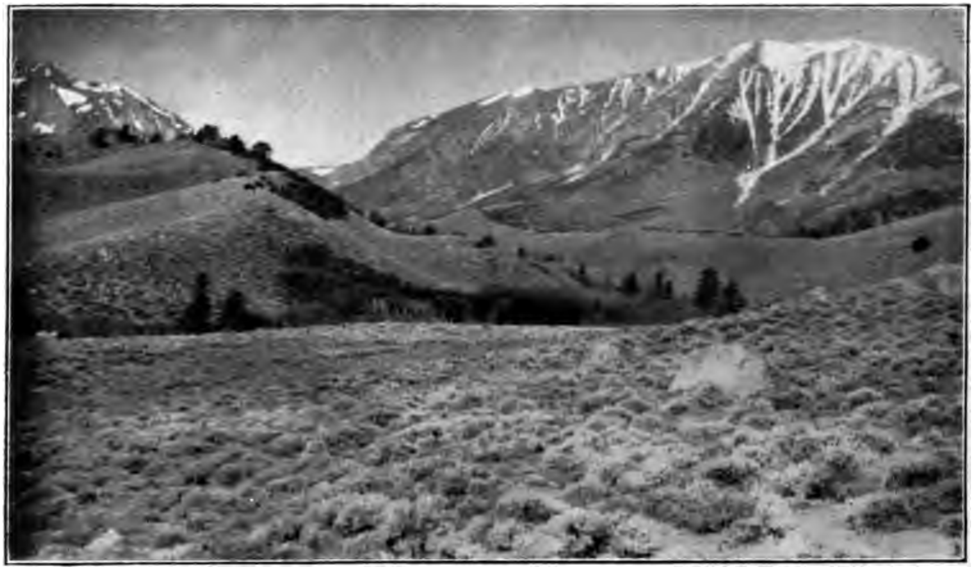


BLOODY CANYON, EAST SIDE OF THE SIERRA NEVADA MOUNTAINS.
(This view is taken from one of the lateral moraines shown in the next picture.)

Do the walls indicate anything as to the depth of the glacier that filled this canyon? Walker lake is seen at the bottom of the valley. A number of low ridges seem to run across the canyon, which suggest a succession of terminal moraines. They are caused, however, by projecting veins of hard rock which the glacier did not wear down as much as it did the softer rock between. A small lake lies behind each dike that crosses the valley. Explain the U-shape of this canyon. Did water help to make this canyon, or did the glacier cut it out of the mountains and leave it as it is?

the gorge, it is seen to be really much narrower than it appears from the distance. The walls in many places are found to be very high, showing that the glacier maintained its volume while confined within them for a period long enough to wear down this deep valley.

The stream flowing down the canyon is small. It is not doing very much rock-cutting, and scarcely nothing at all in carrying away the general rock waste strewn on the floor. It has



THE LATERAL MORAINES AT THE MOUTH OF BLOODY CANYON.

Did the glacier that deposited these great lateral moraines, as it pushed down this valley and out onto the plain, melt rapidly on its sides as it reached the plain? Was the advance of the glacier slow or rapid? Why does the position and relative height and size of the lateral moraines indicate the answer to these questions? These moraines extend out onto the plain for five miles. The one on the left is fully 400 feet high. This was the south side of the glacier. Boulders are left as they were dropped by the glacier.

cut a narrow channel, to which it confines itself, but not deep enough to drain any of several little lakes that are scattered along the canyon. These lakes are held back mostly by dikes, the rock of which is so hard that the stream makes little progress in cutting through it. However, Walker lake, the largest, and the last one below, is a moraine lake.

The lateral moraines extending out on the plain are five miles long. At the mouth of the canyon they are fully 400 feet high, and a mile further down are still between two or three hundred. The trough between them is so wide and deep that the creek which wanders through it looks as if it were occupying a mountain valley. Everywhere along the top and sticking out of the sides of these ridges there are bowlders, lying where the glacier left them so long ago. Some of them are as large as a good-sized room, and all of them are angular. They are scattered over the floor of the valley, too, and the bed of the creek is full of them. But in the creek bed they are rounded and water-worn. Along the foot of the steeper walls of the canyon there is much rock waste. This comes largely from the action of frost which loosens the material from the face of the walls and sends it rolling down to the bottom.

In the Sierra Nevada and Cascade ranges and in the Rockies the ancient glaciers were so extensive that they not only filled the valley but covered the lower mountains, leaving only the higher peaks free and uncovered. They also extended over much of the northern part of the United States, even to the eastern limit. And wherever they were, they left behind them the effects of their vigorous scoring and grinding.

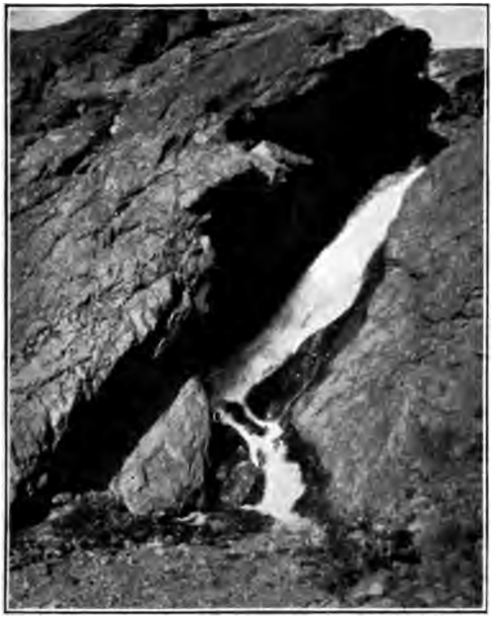
A WATER-CUT CANYON.

A canyon cut by a river is usually narrow at the bottom, often no wider than the stream itself. If the surrounding rock is very hard, the walls rise nearly vertical. And where the rock is of about the same hardness the walls have few offsets and ledges.

If the rock is soft and crumbles easily, the canyon will be much wider at the top, or widely V-shaped. Where the layers of rock differ much in hardness, there are apt to be ledges and overhanging shelves; the canyon grows wider from the rock constantly falling, the stream is full of bowlders, and large angular rock masses are strewn everywhere along the gorge.

The rim of a stream-cut canyon is angular, in sharp contrast to the glacier-ground rim. Frequently there are overhanging ledges where one may stand out over the canyon itself, and from which an object dropped will fall hundreds of feet before striking. There are many places in the Grand Canyon of the Colorado where an object thus dropped will fall more than a thousand feet.

There may be abrupt turns in a river canyon. And where they occur the



STREAM CUTTING A PASSAGE THROUGH A DIKE IN BLOODY CANYON WHICH THE GLACIER DID NOT WEAR DOWN.

Does the water wear away the rock, or is it the sand and broken stone carried by the stream? What other agencies must help the stream by supplying it with grinding material?

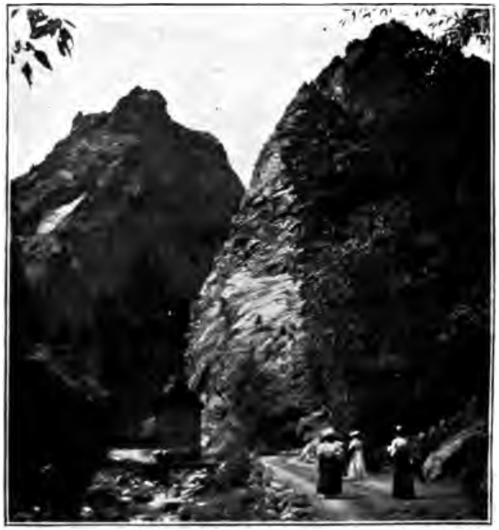
projecting ridge in the angle will be sharp and jagged. When the descent is rapid there will be waterfalls and cascades. Perpendicular falls are more frequent where the different layers of rock vary in hardness. When the rock is nearly uniform, cascades and rapids abound.

The material is widely distributed along the course of the stream. The weathering of the walls of the canyon by rain and atmospheric agencies reduces much of the material to fine particles which are washed into the stream and carried away. The coarser rock waste rolls into the stream, where it is tumbled along by the swift current. This continual grinding of one piece against another wears them away. Those of soft material will be completely worn away, while the harder fragments will have their angles rounded off and become cobble stones and gravel.

SOUTH CHEYENNE CANYON, ROCKY MOUNTAINS.

South Cheyenne Canyon, near Colorado Springs, Colorado, is a good type of the stream-cut canyon. It is short and can be thoroughly explored in a few hours; yet the gorge is deep and shows long-continued and vigorous erosion.

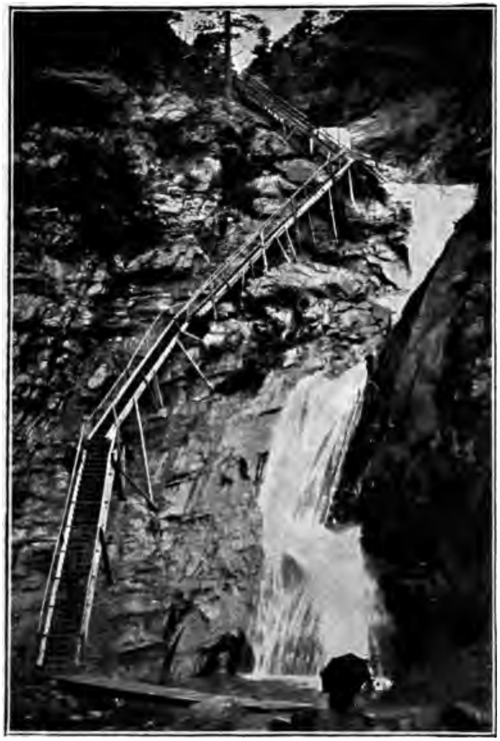
Cheyenne mountain faces eastward, rising abruptly from the plain to the height of nearly three-quarters of a mile. South Cheyenne Canyon opens out through this abrupt front, cleaving it to the very base. It is very steeply V-shaped near the entrance, the walls there being of more compact rock; but farther in are places where the granite disintegrates readily, and there it widens out. In two or three places the granite rots down so readily that there are long slides of the loose material.



ENTRANCE TO SOUTH CHEYENNE CANYON.
Does the steepness of this gateway, worn by the water, indicate that the rock was hard or soft?

A creek still occupies the canyon; but, excepting in time of flood, it is no considerable stream and the amount of rock cutting it is now doing is small. However, it is still active in carrying away the finer rock material that is washed into it by the rains from the sides and from the upper part of its course. About a mile back from the entrance are the Seven Falls. Here there is active rock cutting going on. We can see that the falls are caused by the stream flowing over a harder ledge of rock. The combined height of the falls is several hundred feet. Above the falls the canyon is not so gorge-like, but is more like a valley.

The canyon makes a number of abrupt turns, where the angle of the wall juts out boldly. From the top of Seven Falls two or three of these



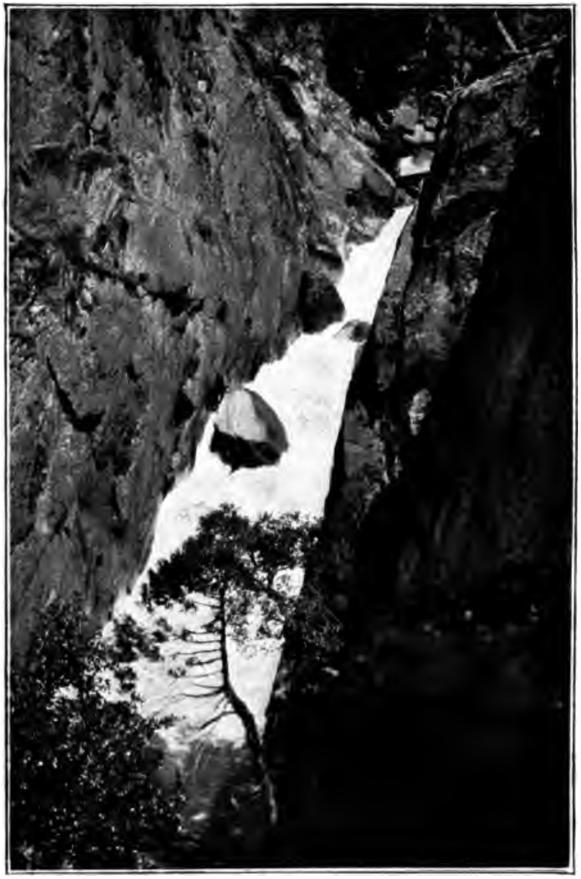
SEVEN FALLS, SOUTH CHEYENNE CANYON

Is the rock harder or softer at the bottom of these falls than toward the top? Where should the soft rock be to so wear down that these seven falls would be united into one high fall?

angle ridges may be seen at once, but there is no view of the stream or road at the bottom of the canyon. The varying hardness of the rock has had much to do in guiding the course of the canyon.

What is true of this short canyon is true in general of all canyon-erosion. There are rivers hundreds of miles long, the entire courses of which are canyons. Everywhere along them this erosion is going on. Somewhere along one of the tributaries a mass of rock falls from the rim or side of the canyon. It rolls and tumbles till it comes to rest in the bed of the stream. Already it has lost some of its bulk, for on the flight down the slope it struck other rock masses. In the stream it is allowed no rest. Sand grinds it away; other rocks roll over it and more fragments are knocked off. Winter comes and frost splits it asunder. Some of the fragments are small and hurry off down stream. The larger pieces are knocked about and separate. The frosts of other winters find them and cleave them into smaller and smaller parts; sand and other small rock fragments continue to grind them. Soon there is nothing left of that rock mass but pebbles, sand, and clay, and much of it is a thousand miles or more away from where it fell.

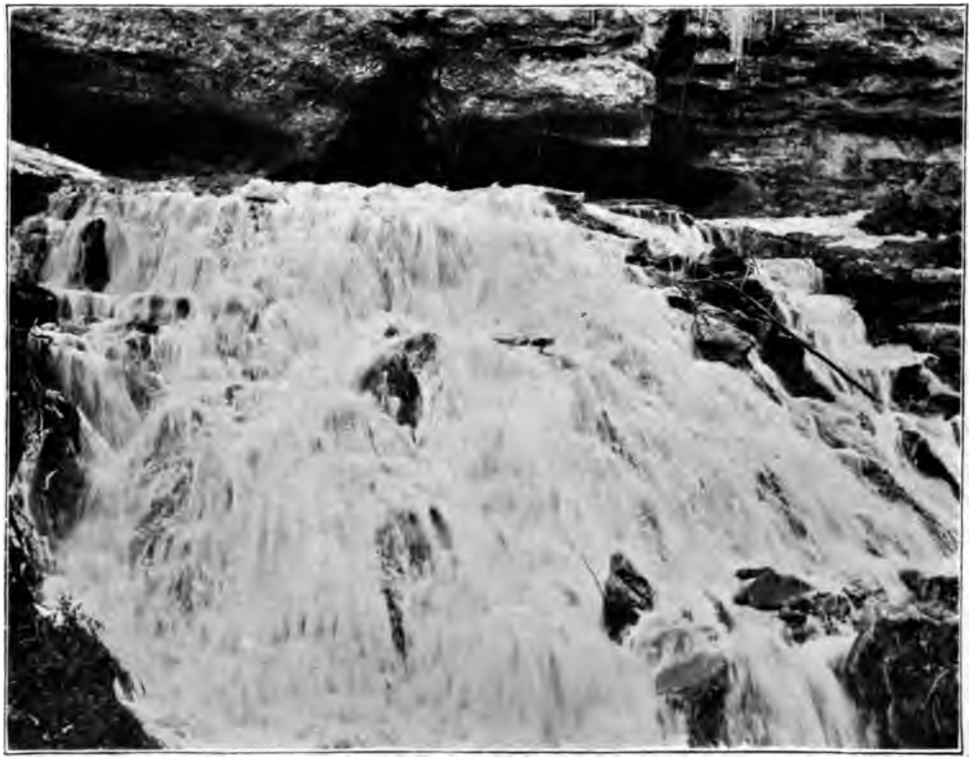
Thus it is the mountains are cut away and shaped. Thus it is the rocks



RANCHERIA CANYON, HETCH HETCHY VALLEY, CALIFORNIA
Why is this gorge being worn through so uniformly that the stream remains a steep rapids and is not cut off into falls?

are torn asunder, ground to pieces, and scattered far and near.

Erosion effects are much more evident in mountain regions than on the plains and prairies, because gravity there gives ice and water an opportunity for vigorous action. But wherever they are present, on plain and prairie as well as on hill and mountain, they are carrying on their work. There are many regions of the earth that today are beautiful and prosperous because of what these forces did ages ago in shaping and transforming the face of the land.



INDIAN SPRING, NEAR THE MISSISSIPPI IN SOUTHEASTERN IOWA.

The cave from which it issues extends back some little distance. Why is the opening wide and low rather than vertical?

III.

THE UPPER MISSISSIPPI REGION.

By the Upper Mississippi Region is meant that part of the basin of the Mississippi which lies north of the mouth of the Missouri River; although, when speaking of the Upper Mississippi River, all the stream north of the mouth of the Ohio is usually meant.

The area drained by the Upper Mississippi is considerably under 200,000 square miles. This is less than half that drained by the Missouri system, and even less than the area of the Ohio System. The length of the river from its sources in Lake Ithaca to the mouth of the Missouri is 1300 miles, or about half that of the Missouri.

North of the mouth of the Ohio the flood plain of the Mississippi is comparatively narrow, seldom exceeding ten miles in width, and in many places is not more than two or three miles. The bluffs rise on either side much more abruptly, in many places presenting bold, rocky fronts, and in some places coming so close together as to make a genuine gorge. The course of the Missouri river as far as the northern boundary of Nebraska has much the character of the Upper Mississippi; but beyond that, it is totally different, and the region through which it flows has the appearance of a much newer land.

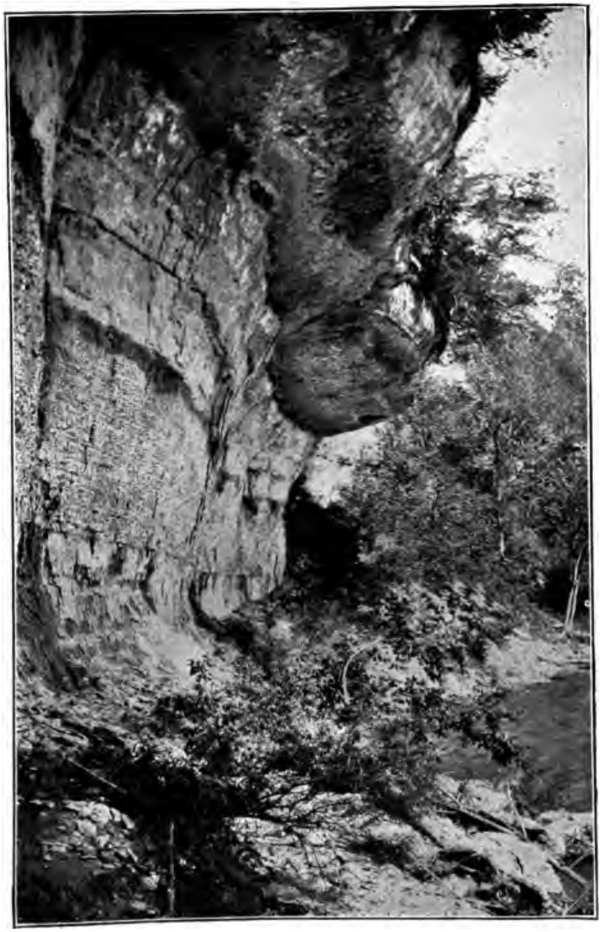
The tributary streams of the Upper Mississippi are of no considerable length, with the exception, possibly, of the Illinois, Des Moines and Wisconsin rivers. It is largely due to this fact that the Mississippi is so grand and majestic. It gathers its waters through comparatively small streams and reserves to itself the dignity and majesty of a great river.

The drainage area of the Upper Mississippi extends to no great distance on either side. But the character of the area is distinct, both in physical features and in products, and may be considered the type of the larger area which embraces the basin of the Ohio lying north of that river and a small portion lying south; likewise, that of the Missouri Basin lying north of the river and extending as far as the north boundary of Nebraska. There are no great stretches of plain like those drained by the Kansas and Nebraska. These tributaries of the Missouri flow for hundreds of miles through an open country where there is no relief to the general level, excepting sandstone hills, bare of vegetation. For the greater part of the year the evaporation is so great in the region of these streams that they carry as much water where they issue from the mountains as they do some hundreds of miles further down their course.

Nor are there mountain regions about the source of the Mississippi like those of the head-waters of the Ohio, and along the Tennessee, the Cumberland and other of its tributaries on the southeast. But instead there are rolling prairies and streams with wide valleys bordered with gradual slopes. The tributaries of the Mississippi rise among gentle hills, and increase in volume until they unite their waters with the great river.

To know how the region has come to have a surface so different from the torrent-scarred slopes of the steep watershed of the mountains, and from the monotonous level of the newer western plains, whose only relief is found in the rough and naked sandstone hills and in the ditch-like channels where flow sluggish streams, it is necessary to learn something about rocks,—where they came from, what they are composed of, how they decay and are carried away, how they have been sculptured and who the sculptor was. The history of their life is the story which tells us whence came the wide, wooded lowlands, the grass-clad hills and the rolling prairies. We shall also learn why there are sometimes abrupt rocky bluffs along the streams, and why throughout a small area just where Iowa and Wisconsin meet, the valley walls are topped with high rock pinnacles and towers, the like of which is nowhere else seen along the Upper Mississippi. Then, too, we shall know what the soil is like, where it came from and how it got in its present position.

THE ROCKS.



ON FLINT RIVER, IN SOUTHEASTERN IOWA.

Overhanging limestone; shale beneath. What agencies are at work decomposing the rock? Why is there so little rock waste at the base?

The rocks of the region are mostly sedimentary; that is, those that have been deposited in water and formed from the material worn from the older granite rock, or by the corals and other lime forming creatures of the ancient sea. These sedimentary rocks lie in more or less regular beds. They are limestones, sandstones, and shales, alternating with one another. The sandstones are much more frequent in the older strata; then the shales come to predominate; and above the limestones make up a larger part of the deposits until the rocks of the coal age are reached; there the rocks are again mostly sandstones and shales.

The strata vary much in thickness. The sandstones usually lie in heavy beds. The shales are either very thick or very thin. Some of the beds are as much as

GRAND CANYON, showing the level strata of sedimentary rocks, which have been worn through by the river.

a hundred feet in depth, while others are less than an inch. The limestones are found in beds, ranging from a few inches to several feet in thickness, but mostly between six inches and two feet. As a rule the layers do not vary much, and they frequently extend for a long distance without any apparent change in thickness.

There are some granitic rocks near the headwaters of the Mississippi and of those tributaries which rise south and west of Lake Superior. These rocks are in the same locality from which much of the material originally came that formed the sandstones and shales found farther to the south.

Granite is composed of quartz, feldspar and mica. When the granite rots down, the feldspar goes to clay, the quartz breaks up into grains of sand, and the mica into small flakes. The decomposed material is washed away by the rain, carried into the streams and distributed along the water courses even to the ocean. The running water sorts over the material; the clay being finest, is carried farthest away. In times of flood, the water is charged with it, and flowing out over flats and lowlands, where the current loses its swiftness, much fine sediment is deposited. The sand being coarser, is left nearer the channel of the stream, and is not carried so far towards the mouth. It is piled up in banks alongside the stream, and even in great bars within the stream itself. Farther up the stream is found the coarser sand; and above that, extending to the very sources, the gravel, made up of fragments of quartz and pieces of jasper and other primitive rock, all rounded and water-worn.

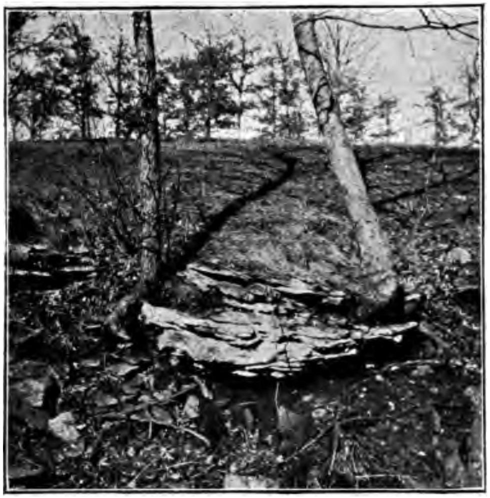
Ages ago the shore of the ocean was next to these granitic rocks in Minnesota. They were then rotting down even more rapidly than in later times, and the resulting clay and sand were sorted and distributed by the waves and currents of the sea, and deposited in extensive beds throughout the region north of the Ohio.

This in brief, describes the rotting down and carrying away of the primitive rock around the sources of the Mississippi. The deposits of sand hardened into sandstone. The beds of clay became shale. When the clay was nearly pure, the resulting shale was fine-grained, such as we find in the beds in Illinois and Iowa where the fine potter's clay is found, the so-called clay being really shale. When the clay contained much sand, the shale was coarse and of little use.

The limestone did not come from the rock material furnished by the granitic ledges in the north, but these strata were built from material secreted by the aquatic life of the ancient oceans. It is mostly composed of the shells of brachiopods, the skeletons of crinoids, and the heavy framework of corals. The brachiopods were salt-water animals with bivalve shells very much like the mussels and clams which we find in the river today, and composed of identically the same material. Indeed, if we had some of the fresh shells of these old brachiopods, they would make pearl buttons that could not be distinguished from those made from clam shells. The crinoids had heavy jointed skeletons of the same material, and in many places the limestone is made up largely of their remains. But perhaps the corals furnished more of the limestone than any other class of old sea animals, and it is not at all unusual to find masses a foot or more in diameter containing uninjured the framework of a coral colony.

The making of the limestone was a long process. It took countless numbers of shells and skeletons. The dashing of the waves on the coral reefs constantly broke off parts of the limestone framework and tumbled the broken pieces over the living forms. The grinding of the shells and coral masses over and under one another gradually wore them away. The material coming from the constant grinding, mixed with the water, formed ooze which either settled down among the spaces in the coral mases where the whole deposit hardened into rock, or was carried off by wave action to settle in quiet water and there form a finer-grained rock.

At times the shore of the ancient sea must have looked like that of the Florida Reefs of today, where the corals are building up extensive deposits of limestone. Then again, there must have been bays and gulfs where the water was quiet, for crinoids only could flourish where there was comparatively still water.



TREE ROOTS GROWING BETWEEN THIN STRATA OF ROCK.

Describe how they tear the rocks loose. In what other ways are these rocks being broken up?

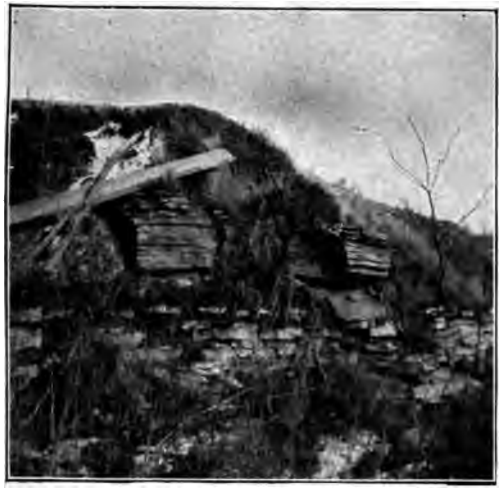
HOW THE SURFACE WAS SCULPTURED.

After these sedimentary rocks were formed and fully hardened, the whole region was finally pushed up out of the sea and became permanent, dry land. Immediately the different disintegrating agencies began to tear them apart and to scatter them far and wide. Of course the topmost layer suffered most. First came the rain. Streams forming, began to cut their channels in the rock and carry the material far to the south. The rain-water washed out of the air carbonic acid gas and carried it down into the crevices and the jointings of the rock, giving it an opportunity to dissolve out the cementing material that held the grains of sand together, and to gradually eat away the surface of the limestone. Running, underground water helped much by cutting away the softer strata, leaving caves and passages. Frost aided in the work.

NEW VALLEY IN THE DRIFT REGION OF IOWA.

The water filling up the crevices and freezing in the winter, pried off blocks of rocks along the channels of the streams, and thus helped to widen the valleys. There were organic agencies, too, which took no small part in the transformation. Roots of trees pried off rocks, and the rootlets finding the smaller crevices, crept down between, and through their efforts to gain sustenance, decomposed the adjoining surfaces. (These different kinds of rock decomposition are going on at the present time wherever the opportunity affords).

Back from the borders of the creek valleys and ravines the top rock rotted down where it lay. The sandstones turned to loose sand and the limestones largely to clay. This decomposition of the rock proceeded slowly downward until there was a covering of the loose material many feet thick. At the top there was usually some loam, accumu-



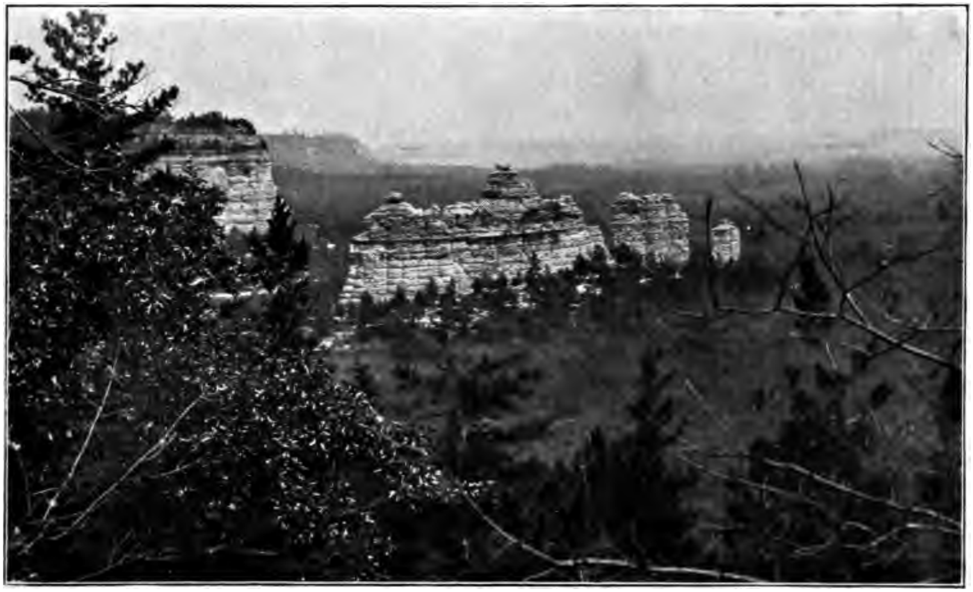
ROTTING DOWN OF LIMESTONE.

What different agencies are breaking up these rocks? What kind of soil is forming? Where is it being deposited?

lated from the decomposed vegetable matter, then a thick layer of soil, either clay or sand, but mostly the former, which grew coarser the deeper one went and which gradually changed to rock fragments and rotten rock, and then to hard, firm rock. The soil at any particular place was pretty much alike all through. In this respect the clay differed greatly from that which covers the rocks today, of which more will be said further on.

Much soil was washed down into the creek valleys and carried away. Where the erosion was not very great and the rotting down of the rock went on faster than the carrying away, the hillsides were covered with a mantle of soil and loose rock material. But where there was much running water, erosion was rapid and the streams kept their valleys clear of loose material, and were bordered by more or less rugged rock walls.

The layers of rock exposed on the face of the cliffs bordering the channels of the streams, generally varied much in hardness and in the material of which they were composed. Frequently some were hard limestones, while others were soft shales or sandstones. The shale or sandstone wearing away, left a shelf of limestone projecting, which, deprived of its support, broke away in great masses. Many of the shaley layers kept on decomposing after the streams had cut their channels down past them and were running at a lower level, the decomposition resulting from the atmosphere acting on chemicals contained in the shale; also from freezing and thawing.



Photographed by W. W. Atwood.

TYPICAL SCENE IN THE DRIFTLESS AREA OF WISCONSIN.

What shows that the region was never occupied by a glacier? What can you say of the forces exerted by the agencies at present tearing down the rock?

THE LANDSCAPES.

The long-continued rotting down of the rocks and the carving action of the streams, changed the face of the land from a level surface to one of hills and valleys. The valleys were much deeper than those of today, and, consequently, the hills much higher. There were many pinnacles, towers, and bold buttresses where the rock had been harder and had successfully resisted the attacks of the decomposing agencies. There was a certain roughness and ruggedness to the landscape that gave it an unfinished appearance. Something was needed to subdue the roughness and round out the surface into lines of symmetry and beauty.

This needed agency came in the form

of a great glacier that moved down from the north and overwhelmed the face of the land. It cut down the high hills, tore away the projecting rocks, ground many of the steep cliffs into gentler slopes, carried off the loose mantle of soil, scraped and polished the hard rock beneath, and filled up the valleys with the debris. Beside the material it tore from the local rock, it brought down much from further north. There was so much of this material that the glacier did not seem to be able to take care of it, so deposited it beneath and pushed on over it. The material thus deposited is called drift, and it is spread all over the Upper Mississippi region, excepting the small spot, already spoken of, along the Mississippi just where Iowa and Wisconsin meet, which is known as the Driftless Area.

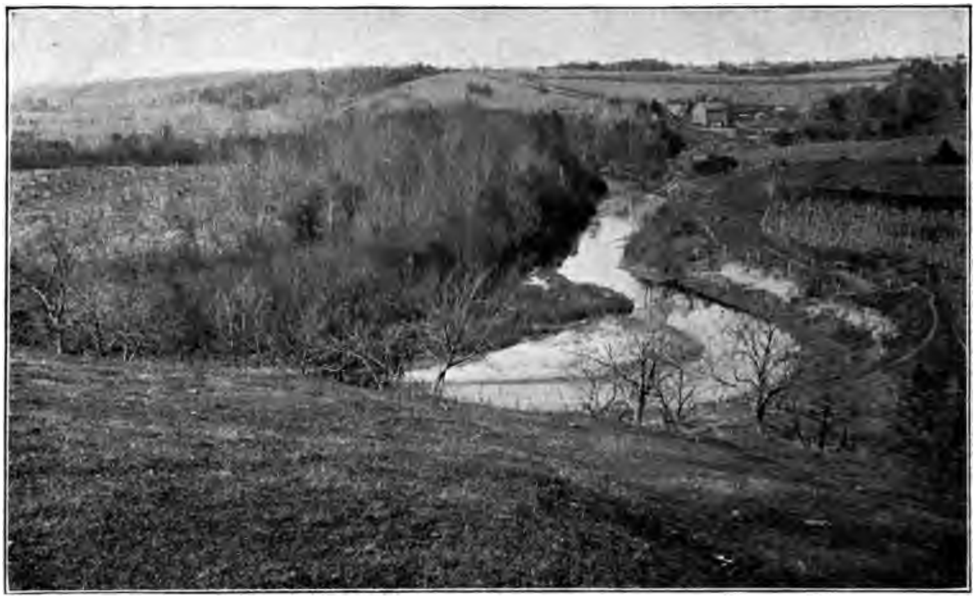
The drift is a compact clay. No wonder it is close and dense, since it once bore the weight of the great glacier. It is full of angular rock fragments, many of which are scratched and polished. Some of them have several perfectly flat faces, showing how they have been held in the ice while being dragged over other rock surfaces. The glacier deposited so much of this drift, that when, after thousands of years, it melted away, the surface was left covered for many feet in depth. Forty or fifty feet of drift is nothing unusual, and sometimes it is two or three times that.

When the glacier finally retreated, every feature of the old landscape was gone. The surface was pretty much on a level, and the system of drainage had to be worked out all over again. But the new work was much easier than the old. In many cases the streams found the old water courses, and, cleaning them out, established a basin pretty much the same as it existed before the glacier came. But sometimes the streams found the old channels so thoroughly choked that they were forced to find another way. Then they would have to cut down through the rock, and at such places you will find gorges. When you see a stream flowing in a narrow gorge between two perpendicular walls of rock, you may be sure that here it is following the channel that has been cut in recent times. If it is flowing in a wide valley bordered by gently sloping hills, you may believe that it is there occupying the bed that an ancient stream made long before the glacier changed the face of the land. Along the Mississippi there are a few of these gorges of recent origin. One of them is near the southeast corner of Iowa where the river flows for some twelve miles through a new gorge, the high rocky bluffs of which are scarcely more than half a mile apart. The old river valley is to the westward. It is filled with glacial debris, and on the surface of the land two hundred feet above where the bottom of the old channel was, are fine farms. Between the steep walls of the new gorge the river flows over a rock floor and forms what is know as the Lower Rapids of the Mississippi. During low water steamboats cannot pass over these rapids, and a canal has been built along the west shore in order that traffic may not be interrupted.

After the streams had succeeded in re-excavating their channels, and grasses and trees had once more made their home in the land, the region took on a loveliness nowhere exceeded in nature. The broad valleys, the gentle hillside slopes and the undulating prairies have a beauty that is all their own. When the glacier moved down upon the land it found a landscape of deep valleys, high hills and rock forms standing in bold relief. When it had finally receded for good and the resculpturing was completed, the landscape was one of symmetry and beauty. For a time nearly the whole of the region was covered with forests, occupying much of what is now plain, bringing with them a richness that is greater than mines of gold and veins of silver; for to them we owe the rich mantle of loam which makes possible the agricultural wealth of the region. Later the forests retreated to the bottoms and hillsides of the streams, and the adjacent uplands, where they were flourishing when the white man came, and where they are still found whenever the hands of the same race have left them unmolested.

The mantle of drift over much of the region is so deep that it is only in the vicinity of the principal streams that the channels are cut down to the rock beneath. So there are great stretches of territory where no rock is seen, excepting such as may be shipped in. One such region in Minnesota and northern Iowa is hundreds of miles in extent.

While the landscape of rolling prairies, rounded hill-slopes, broad valleys, and wooded lowlands may be taken as



Photographed by Ernest Hanson.

A TYPICAL SCENE IN THE DRIFT REGION OF IOWA.
What shows that the valley is an old one?

the distinctive type of the region, yet there is some diversity, and there are certain localities where the surface features are entirely different. Such are the Driftless Area of Wisconsin and Iowa, already spoken of, and the Lake Region of Minnesota.

In the Driftless Area rock pinnacles abound. The soil is clay that came from the rotting down of the local rock and is entirely different from that of the drift regions. The borders of the Area are where the ancient glaciers halted in their forward march, or where the flank of the ice-sheet touched as it moved by on either side to the southward. It seems almost as if the Driftless Area, with its bold rock towers and pinnacles was purposely left untouched by the glacier in order that

Photographed by Warren Upham.

VIEW IN THE LAKE REGION OF MINNESOTA.

we might know what this whole region once looked like in ancient times.

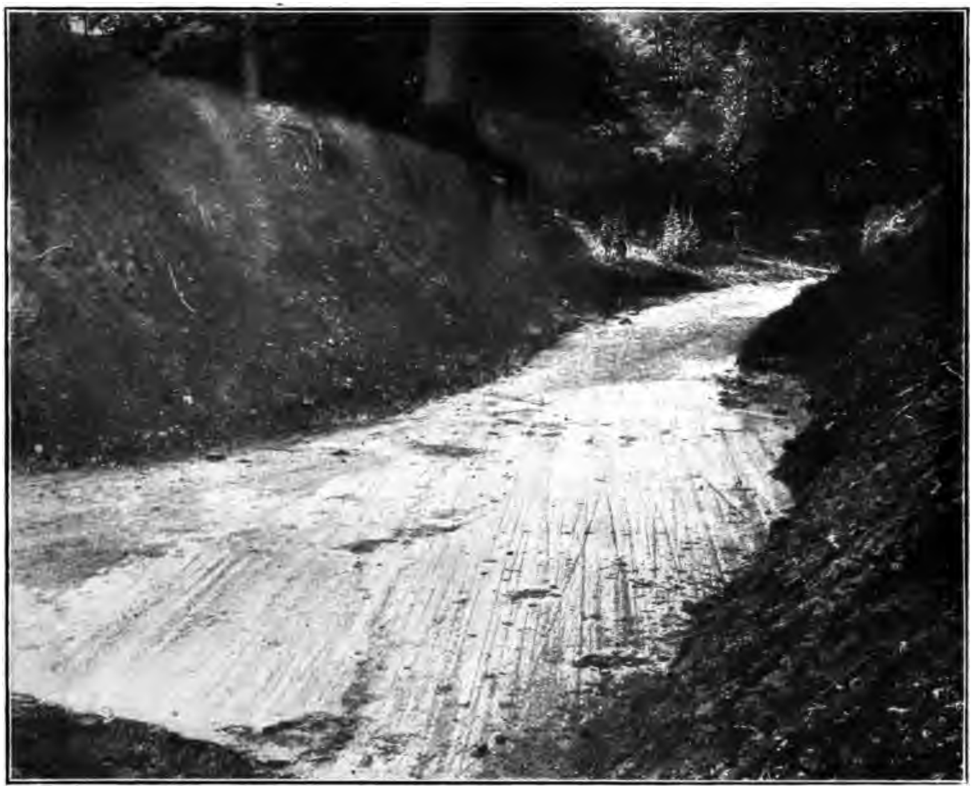
A strip of country beginning in the northwest part of Wisconsin and extending westward nearly across the central part of Minnesota is known as "The Lake Region." Here are the headwaters of the Mississippi. It is estimated the area contains not less than ten thousand lakes. The railroads running to the north and northwest from St. Paul and Minneapolis pass through this picturesque country, and looking from the car window the traveler notes at once the contrast to the scenery in Iowa and Illinois. If he knows that the glacier helped shape the more southern landscape, he will be interested in learning that the Lake Region, too, owes its existence to the same agency. These thousands of lakes are hemmed in by the clay and rocks dumped there by a glacier,—a glacier that existed perhaps not half so long ago as that which devastated the land of southern Iowa and central Illinois, yet one whose time in the past must be numbered by thousands, perhaps tens of thousands, of years. The front of this old glacier was very irregular, and lingered long in the region where the lakes now are, dumping much clay and rock waste, and leaving behind the broken and irregular lines of morainic material many depressions where water has collected and formed lakes. These lakes have outlets, and frequently a number are connected and have a common outlet. But the region is so flat that the streams have not deepened their channels rapidly and but few of the lakes have been drained in the natural process of working out a drainage system. The outlets of many of the lakes flow only at the time of the melting of the snows, and during seasons of excessive rainfall.

There is also another small lake region on the line separating Minnesota from Iowa which was similarly formed, but by an older glacier. But here the working out of the natural drainage system has proceeded much farther, so the lakes are not so frequent and there are many lake beds left dry by the constant filling up by the soil washed in, and the gradual cutting down of the channel of the outlet. These dry lake beds are some of the finest farming land in the world.

THE SOILS.

The wealth of the region is in its soil, which is of several different kinds. Drift, loam, loess, sand and alluvium are the principal ones. Each deserves description somewhat in detail, — where it came from, what it is like and the crop it is best adapted for.

Something has already been said of the drift,—that it is a hard, compact clay full of rock fragments. It is spread all over the region, (excepting the Driftless Area), reaching to the Missouri river and in some places a little beyond, and as far south in Illinois as a line running east from St. Louis. It lies just as the glacier left it, often on the hard rock from which the glacier had first scraped all the loose ma-

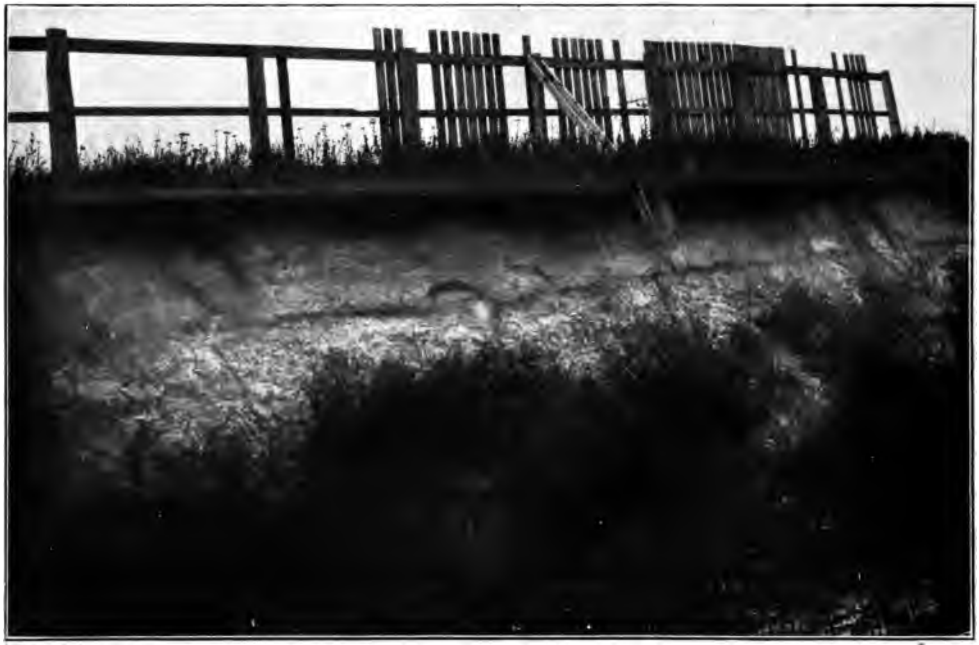


GLACIER-PLANED LIMESTONE NEAR KINGSTON, DES MOINES CO., IOWA.

What would indicate that the glacier did not move constantly in one direction, but changed its course? Did it change its course more than once? Which grooves were made last? What shows that the soil in the banks is drift?

terial and then ground down as level as a floor. If we could strip all the drift from some large area of level country we would see this hard rock floor extending sometimes for long distances. When the Chicago Drainage Canal was dug, this flat glacier-ground rock floor was uncovered in many places.

Taking the whole region, the drift will probably average not less than 50 feet in depth. Towards the south it is much thinner than this, but in Wisconsin and Minnesota it frequently reaches 200 feet, or more. It is quite generally covered with loam, and usually is seen at the surface only along the bluffs



Photographed by I. A. Williams.

LOAM LYING DIRECTLY ON DRIFT.

In what ways does the loam seem to differ from the drift? The loam here is probably three feet deep. Is the land in this region apt to be rich or poor?

A BLUFF OF DRIFT.

What seems to indicate that this bluff is all drift?

which border the streams. Yet it is nearly everywhere very close to the surface. A well dug on the prairie will be mostly in the drift. Even in digging a cellar it is nearly always reached.

On account of its close, compact nature it makes an excellent bed for the loam to lie upon, for it allows the moisture in the ground to drain away but slowly. It takes moisture slowly, but retains it well, thus acting as a reservoir in a time of drouth. The structure of the drift is such that when it is thoroughly saturated with water, it slips and slides easily. This is why bluffs of it are always sloping. It is the cause, too, of many terraces slipping.

On account of it being so seldom the

top soil, the drift is used very little for the cultivation of crops. This is fortunate, for while it contains much plant food, it is very difficult to till, and ordinary plants and vegetables find trouble in getting at the food which it does contain. The most useful purpose of the drift is to act as an underlying reservoir for the loam.

The loam is a black soil that is made on the drift or the local rock waste from decomposed vegetable matter. In any forest you may see the making of it constantly going on. The fallen leaves and dead branches and prostrate trunks of trees are ever rotting and adding to the covering of vegetable mold.

The loam is forming, too, in swamps where mosses and other water plants are constantly dying and sinking to the bottom, together with the fine particles of earth which settle from the water brought in by the streams. In the course of many years the swamps are thus filled up, and their outlets being continually cut deeper, in time they become dry land covered with a thick layer of rich soil. Many swamps are artificially drained in order to get the land for farms.

Loam is the most productive of all the soils, and because Illinois and Iowa are almost completely covered with it, they comprise the finest corn region in the world. Loam, however, is easily drained of its moisture, and it owes much of its productiveness in this region to the drift upon which it lies, and which, as previously noted, holds moisture well. The loam varies much in thickness, from a few inches to several feet. It does not rest directly upon the hard, compact drift, but usually blends with it through a foot or more of subsoil that is clayey in its nature, but which is much looser than the drift. This sub-soil is the first soil that formed on top of the drift, mixed with the drift, largely through the agency of roots and earthworms.

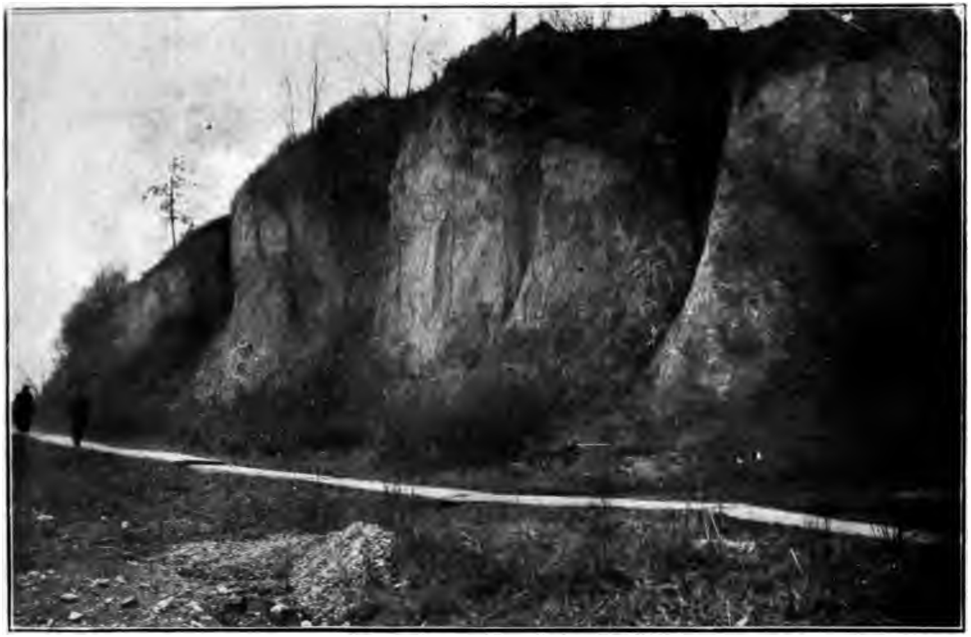
There is but little loam found on steep hillsides, because it washes away easily, and the rains will not allow it to accumulate. But out on the more level prairies, it is sometimes several feet thick, because it was allowed to accumulate there undisturbed. It is probable that either a forest once grew there, or else it was a marsh. However, there are some people who believe that the loam on the prairies may have

Photographed by A. S. Williams.

VIEW ON LAKE MINNETONKA.
What kind of soil-forming is going on here?

come from the decaying grasses, flowers, and weeds during the long period since the time of the glacier.

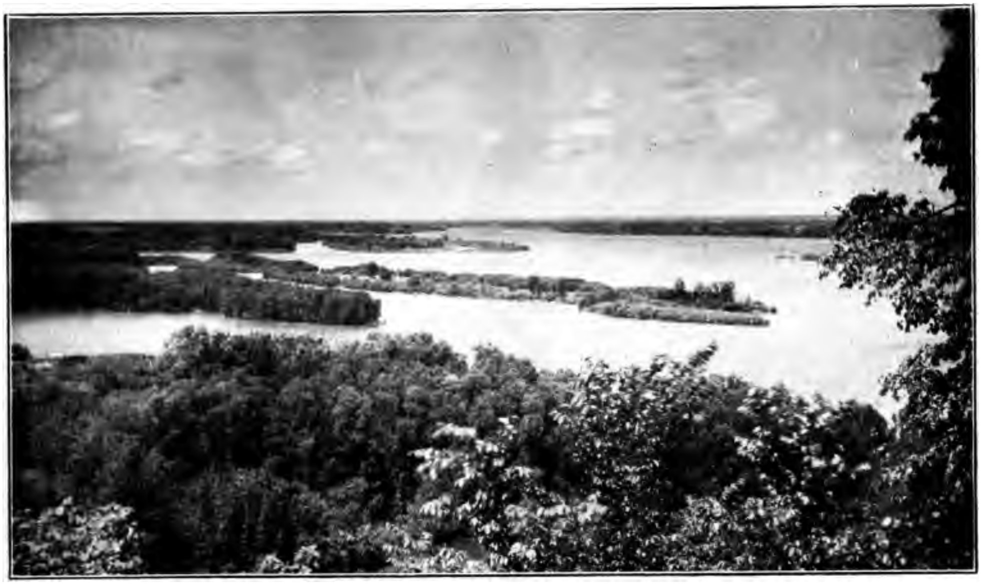
Along the Mississippi and its principal tributaries there are deep deposits of *loess*. This is a fine-grained soil, usually light yellow or cream color, much looser than the drift, but more compact than loam. Its structure is entirely different, too. Banks of drift or loam will slip when water-soaked. But loess will stand for a long time, even as a perpendicular wall. It is only found on the high bluffs bordering the streams, and is always more extensive on the east bluff than on the west. There are different theories about its origin. One of the most reasonable is that after the glacier melted away, the country was a great mud plain; this gradually dried on the surface and the winds sweeping over it gathered up



A BLUFF OF LOESS.
In what ways does this differ from a bluff of drift?

great quantities of dust and piled it up along the streams. But some people think that it was deposited as the glacier retreated and that the water coming from the melting glacier had something to do with it.

Wherever the loess came from, it does not lie in great stretches like the drift or the loam. It is even not continuous along the streams. But where it does occur it is usually many feet thick. Strange, too, it is deepest on the very highest bluffs. While it is a better soil than drift, it is not as rich as loam, and is not suitable for corn and many other farm crops. It is best adapted for fruit raising and is considered the finest of all soils for grapes.



Looking up the Mississippi from the High Bluffs at Burlington, Iowa, showing Lowlands and Islands. The soil is sand and alluvium. Where is the sand? Where the alluvium?

Hence the high bluffs along the Mississippi are in many places covered with vineyards.

The sandy soils of the region are mostly connected with the flood-plains of the rivers. If it is nearly pure sand, it is one of the older deposits of the flood plain and usually lies along the base of the bordering bluffs above the reach of the highest stage of water of the present time. There are some stretches of sand found on the upland. But an examination will always show that they are occupying a place where once there was a stream. It is not unusual to find such places bordered with a sand ridge which the wind piled up thousands of years ago. Sand produces the finest melons and sweet potatoes, but to insure a good crop, frequent rains are needed. The soil drains rapidly and the evaporation from its surface is fast.

There remains yet the alluvial soil

of the flood-plains to be mentioned. This soil is composed of the fine silt which a stream deposits on its flood-plain when it is out of its banks. It is made up of very fine sand, clay and loam that have been washed into the river from the upland, and decomposed vegetable matter of all kinds. It is exceedingly rich and will produce big crops of corn and vegetables. However, where it is not protected from overflow by levees, the floods that usually come late in the spring and which frequently continue far into the summer, may keep it covered until the time of planting is past. Thus frequently there are seasons when there is no crop at all. It is only on the higher parts of the flood-plain that regular farming is carried on.

Most of the flood-plains of the Upper Mississippi are so narrow that so far only a few of them are protected by levees. They are still largely covered by lowland timber and are much cut up by sloughs and shallow lakes that occupy old channels where once the river flowed.

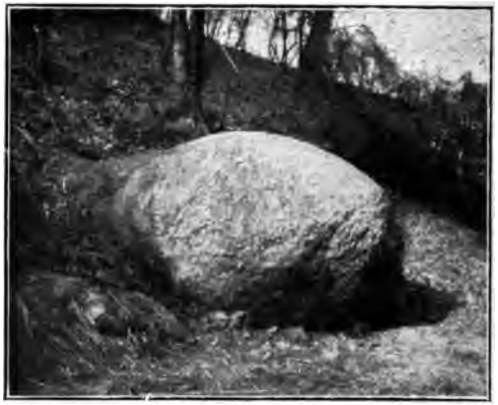
SOME FIELD AND EXPERIMENTAL WORK.

I.

Look for a granite bowlder that is rotting down. Sometimes you will find one which is decaying so fast that you can dig into it with your fingers.

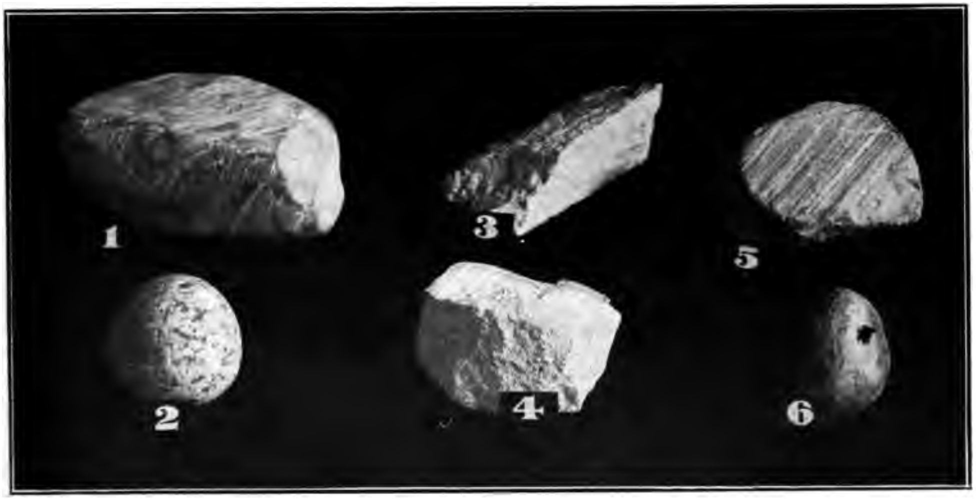
Pick out the fragments that are going to become sand and gravel. Crush some of these with a hammer to see if they will make sand.

Are any of the fragments of a clayey nature?



A GRANITE BOWLDER THAT IS ROTTING DOWN.

Why is there more rock waste on the upper side than on the down-hill side?



Of these fragments, which are from the drift? Why? Which are from a creek bed? Which are freshly broken pieces?

Can you find any flakes of mica?

Sift some of the finely decayed material in the wind and watch what becomes of the mica.

Is mica likely to be found in all soils?

II.

Make a collection of drift, loam, subsoil (lying between the drift and the loam), sand, gravel and alluvium; and wherever it is possible, of loess. Get as pure samples as possible.

Place about the same amount of each sample in separate glasses containing 5 or 6 times as much water. Stir them all thoroughly. While they are settling, watch them carefully.

In which glass will the water remain clear however much you stir it?

Which will be the first of the others to become clear? Why?

Note which is the last to clear. Reason out why.

Which has the most sediment clinging to the sides of the glass? What does this show?

III.

Find a pile of fresh clay where a cellar is being excavated, a well being dug, or the grading of a road is going on. Watch the sorting of material that takes place during a rain when rivulets of water are cutting into the soft earth.

Where is the coarse material found: near the heap of earth, or farther away?

How far away may some of the material be carried?

See how many different grades of material (as to fineness) you can find.

Find a pool or mudhole into which some of the soil is washed and where it is allowed to settle undisturbed. After the water has evaporated and the mud dried, cut down through the dried earth carefully and find whether it is in layers. Account for the different layers.

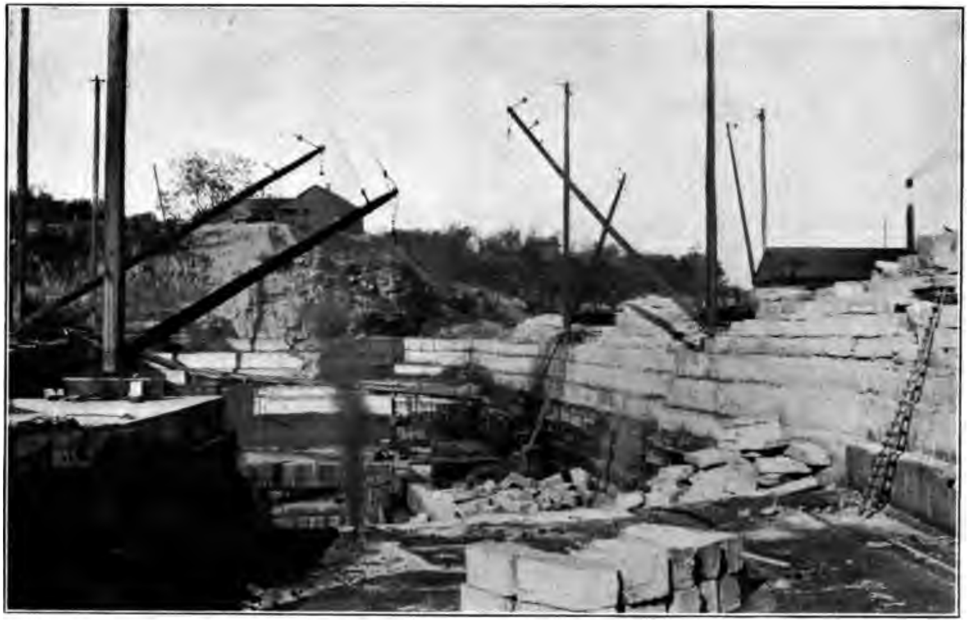


Photo by S. Calvin. LIME STONE QUARRY AT CEDAR VALLEY, IOWA.
Note the smoke from the engine at the bottom of the deep pit in the center of the quarry. What can you say of the regularity of the rock layers and the method of handling the blocks of stone?

FORESTS.

The forests of the Upper Mississippi Region deserve more extensive mention than there is space here to give them.

For the first five hundred miles above St. Louis, the flood plain of the Mississippi and the lower courses of its tributaries are quite generally covered with timber. The common trees are the elm, ash, sycamore, soft maple, cottonwood, box-elder, birch, island hickory, hackberry, bitternut (pig-nut), willow, and to some extent the black walnut, butternut, honey locust, hard maple and linn. The pecan also flourishes for some two hundred miles north of St. Louis.

Along the higher creek valleys,

running up the hillsides, and frequently extending a considerable distance out on to the uplands, grow the white oak, red oak, bur oak, and several other less common species of oak, elm, hard maple, pignut, linn, honey locust, black walnut, butternut and other specimens of less note.

While there is not space to speak of each of these trees in detail, yet many of them are of such importance that some brief remarks at least should be devoted to them.

The nut trees are the hickories, pecan, black walnut, and butternut. The nuts from these trees have considerable commercial value. The hickory nut probably ranks next after the English walnut of all the nuts produced in our country. Although this place might be disputed by the pecan, which is raised in large quantities further south. After the hickory nut and pecan, the black walnut ranks next in value as an article of commerce. However, the nuts from all these trees are found in the market.

The lumber from the different trees is used in the manufacture of various articles, some being especially well adapted to one kind of use, while others are best fitted for some other particular purpose. Oak, maple, and birch are used for fine furniture and for interior finishing in houses. Formerly black walnut and butternut were much used for interior finishing, and the black walnut also for furniture. But the black walnut is now so scarce that most of it is bought up for the manufacture of gun stocks, it being the best wood found anywhere in the world for that purpose.

Soft maple, elm and ash are much used in the manufacture of cheap furniture. They are now also furnishing much of the material for basket making, which industry is being developed at various points in the region. The willow is also used in basket making.

The early settlers took up their homesteads in the timber and along the streams. There were various reasons for this, one being that many came from the states further east where the best land occupied a similar position. Then, too, the timber furnished them material for building and fuel. Game was more plentiful and an important item to people making a home in a new region. Many settled along the creeks where there was water power, and built saw-mills to supply the needs of the immediate neighborhood in lumber. Many of the first buildings, though frequently built of logs, were finished with lumber from the local forests.

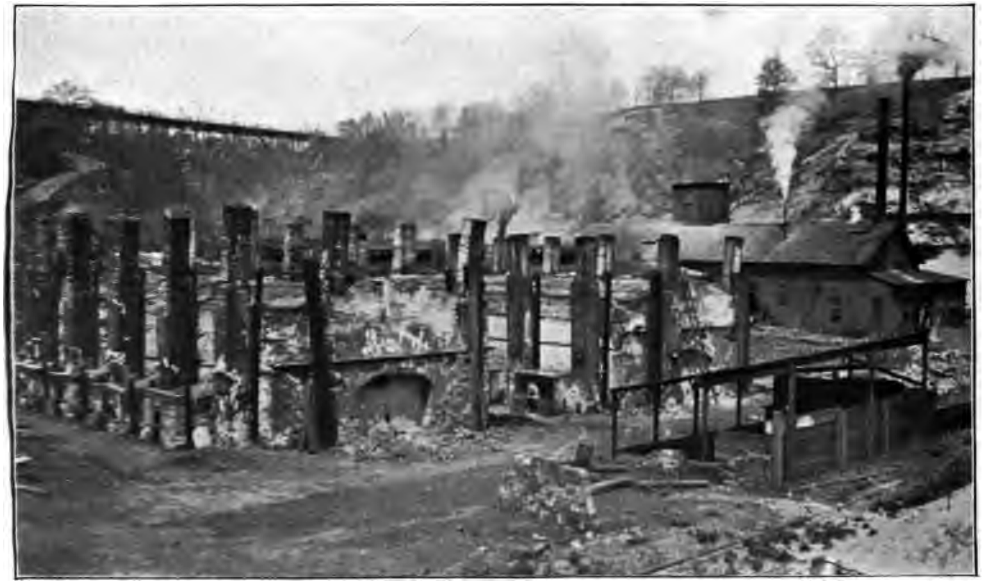
Covering the northern part of Wisconsin, and a considerable portion of Minnesota, are the pineries, which for many years have supplied the whole Upper Mississippi Region with lumber, beside furnishing much for the country south and west. The most valuable tree in these forests is the white pine. In the early years of lumbering it was practically the only tree cut; but it was found so valuable for many purposes that the big supply demanded has practically exhausted the forests. White pine is especially valuable for pattern making, and no other wood which is easily and cheaply obtained has been found to take its place for this purpose.

So great has been the drain of lumber from the northern forests, that nearly all of the region has now been cut over. What there is left is mostly "Norway pine" and tamarack, both greatly inferior to the white pine. It

HAULING LOGS IN THE PINERIES OF MINNESOTA. The engine is partly on runners.

will be but a very few years until this supply, too, will be exhausted.

The lumber industry has been a great business and has employed thousands of men in the different parts of the work. The trees are largely cut and hauled to the streams during the winter months, when the ground is deeply covered with snow. When the spring floods come, the logs are floated down the creeks into the larger streams and to the saw-mills, which are located at convenient points along the river; or collected into booms somewhere on the lower courses of the tributaries of the Mississippi and made into rafts, which are then towed by steamers to the mills located farther down the Mississippi, some of which are as far south as Quincy, Ill., and Hannibal, Mo.



KILNS OF THE GRANITE BRICK CO., BURLINGTON, IA.

Hard paving bricks are burned in these kilns. In the background at the right is the factory where the clay is worked and moulded.

BUILDING STONES AND MINERALS.

Limestone is widely distributed over the area, but in many places, as through the north-central portion of Iowa, it is so deeply covered with drift, that it is cheaper to ship stone from a distance than to open up quarries. Also in the coal region it is covered by many hundreds of feet of shales and inferior sandstones. There are many noted quarries of limestone, those of Joliet, Ill., and Anamosa, Cedar Valley and Stone City, Ia., being the best known. From these quarries large quantities of fine building stone are shipped to points in the adjacent territory. The rock from these quarries is especially well adapted for bridge piers and abutments.

At many places the limestone is of a quality well adapted for making lime. There are well known lime kilns at Quincy and Port Bryon, Ill., Hannibal, Mo., and at Lime City, Ia. Thousands of barrels of lime are annually shipped from these places.

In many localities in Wisconsin and Minnesota sandstone furnishes good building material. Also in these states there are well known granite quarries from which much stone is shipped for building and monumental purposes. The quarries at Montello and Wausau, Wis., and at St. Cloud, Minn., furnish especially good grades of granite.

There is an extensive deposit of gypsum near Ft. Dodge, Ia., and large quarries are worked there. The gypsum is used in making plaster of paris and a material known as "stucco," large quantities of which were used in constructing the great buildings at the Louisiana Purchase Exposition at St. Louis in 1903-1904.

Lead is mined in limited quantities at Galena, Ill., and Dubuque, Ia. These mines have been worked for about a century, and in the earlier years of their existence formed an important source of supply; but since the development of the great lead mines in Missouri and in Idaho and Montana, the quantity of lead produced at the Galena and Dubuque mines is comparatively small.

In Minnesota there are some of the most extensive deposits of iron ore in the world, and nowhere else is it found where it is so easily mined. The ore occurs in beds of many square miles in extent, and sometimes hundreds of feet in depth, and is so loose in structure that it is scooped up with steam shovels, like so much clay or sand, and dumped on ore cars that are run down a railway built into the open mine.

The coal fields of Illinois and Iowa are very extensive, that of Illinois occupying almost two-thirds of the state, and that of Iowa about one-fourth. They are extensively worked, coal being one of the best paying industries of the region. The business is carried on at hundreds of places and it is not possible to mention all the important centers. Belleville, Ill., and Centerville, Ia., are two of them which are widely known.

Photo from the International Harvester Co.
TWENTY SELF-BINDERS AT WORK IN A MINNESOTA WHEAT FIELD.

CROPS AND LIVE STOCK.

There is less waste land in the Upper Mississippi Region than in any equal area anywhere in the United States. While the soil is adapted for many different kinds of crops, yet the great crop is corn. Illinois and Iowa, with the adjoining states, comprise the greatest corn region in the world. In 1906 Iowa produced 273,275,000 bushels, and Illinois 347,169,000 bushels. 300,000,000 bushels is no unusual yield for either state. The value at 50c a bushel would be $150,000,000, which is about double the value of all the gold mined in the United States, including Alaska, in one year. When it is remembered that this is the value for the corn of one state alone, and that there are several other important crops and great numbers of live stock marketed, it can be readily seen that the value of the annual products of either Iowa or Illinois reaches an enormous sum. Considerable corn is now being raised in Minnesota also. Formerly the northern edge of the corn belt was

HARVESTING OATS, ILLINOIS.

near the southern line of that state, but by the production of hardier varieties, the zone is continually widening to the north.

Wheat, oats, rye and barley are all grown throughout the region, oats being very generally raised in all parts for feed as well as for the market. Minnesota is the great wheat state of the region, and many farms there contain thousands of acres, devoted exclusively to wheat raising.

The hay crop is bountiful, and the pasturage is as fine as can be found anywhere. Great numbers of hogs and beef cattle are raised for the market. Many cattle are brought from the western plains to Iowa and Illinois and fattened on corn, before being sent to Chicago and other live-stock markets. Iowa leads all the states of the Union in the number of hogs annually sold.

It is a region, too, in which there is much fine stock, especially hogs and cattle. Dairying is an important industry, and butter which is made in the dairies of Wisconsin, Iowa and Northern Illinois, takes highest rank in the market.

The agricultural colleges at Ames, Ia., and at Champaign, Ill., are noted for the advantages offered in agricultural education and for their experimental farms. At these schools boys and girls are taught the best methods in agriculture, stock-raising, dairying and household economics.

PACKING HOUSES AND CANNING FACTORIES.

Closely connected with the agricultural interests are the meat packing houses. The most important one of these centers located within the Upper Mississippi Region is East St. Louis. But the region is surrounded by other great centers, such as Kansas City, Omaha and Sioux City on the west and Chicago on the east, the latter drawing a large part of its supply from Iowa, Illinois and Wisconsin. At Ottumwa, Ia., there is a very large packing house.

Canning factories are widely scattered over the region. At Bloomington, Ill., and Vinton and Wapello, Ia., and at many other points, large quantities of tomatoes and sweet corn are canned. On account of the rich alluvial lowlands along the Mississippi, where cucumbers, cabbage and other vegetables are raised in great abundance, there are many pickle works. Some of the largest centers are Alexandria, Mo., and Burlington and Muscatine, Ia.

DISTILLERIES.

The distilleries at Peoria furnish a market for millions of bushels of corn annually. So vast is the industry that railroads have been built into the city from the distant parts of Illinois and adjoining states for the express purpose of bringing in grain. One of these roads reaches into the corn fields of central and northern Iowa.

FRUIT.

There is a great variety of fruit. For the most part it is abundant in quantity and excellent in quality. There are usually more apples produced than find a market within the region. The orchards of central and western Iowa are famous for the beauty and flavor of the fruit.

Pears and plums flourish generally

Photo from the Iowa State College of Agriculture and Mechanic Arts.
STUDENTS AT WORK ON THE EXPERIMENTAL PLATS.

throughout the whole region, as do the smaller fruits, such as cherries, currants, raspberries, blackberries and strawberries. The peach crop is uncertain on account of the winter-killing of the trees and the blasting of the fruit buds in early spring.

The vineyards of the loess bluffs along the Mississippi river are almost as famous as those of the Rhine. They were planted by those who came from the "Fatherland" for that purpose. For years the grapes were mostly made into wine, but now there is such a demand for the fresh fruit that the crop is largely shipped, most of it going to more northern markets. Thousands of tons of grapes are thus annually disposed of. Some of the finest of these vineyards are on the bluffs near the town of Nauvoo, Ill.

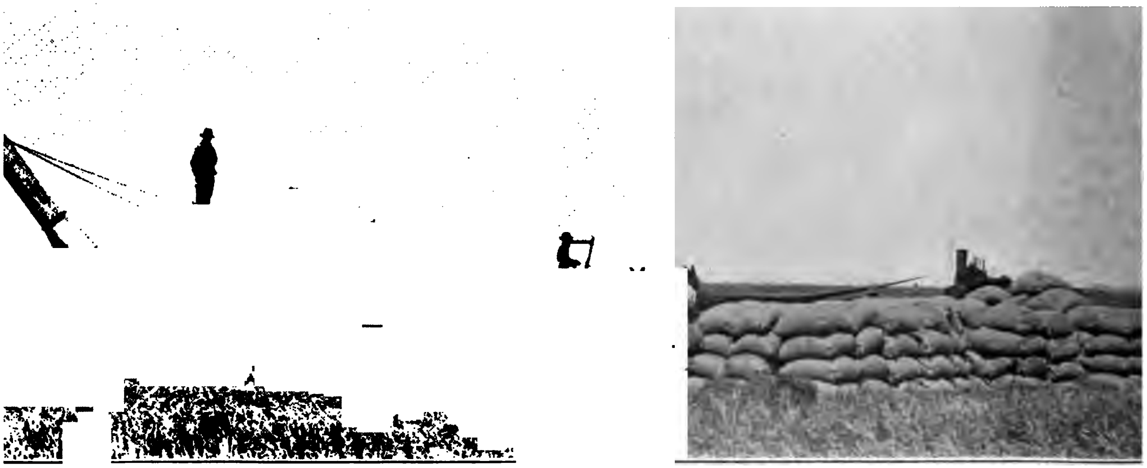


Photo from the Minneapolis Threshing Machine Co.
THRESHING WHEAT IN MINNESOTA.
Note the wheat in sacks ready for the market; the wagons with racks for hauling the bound grain to the thresher; and the engine which runs the thresher

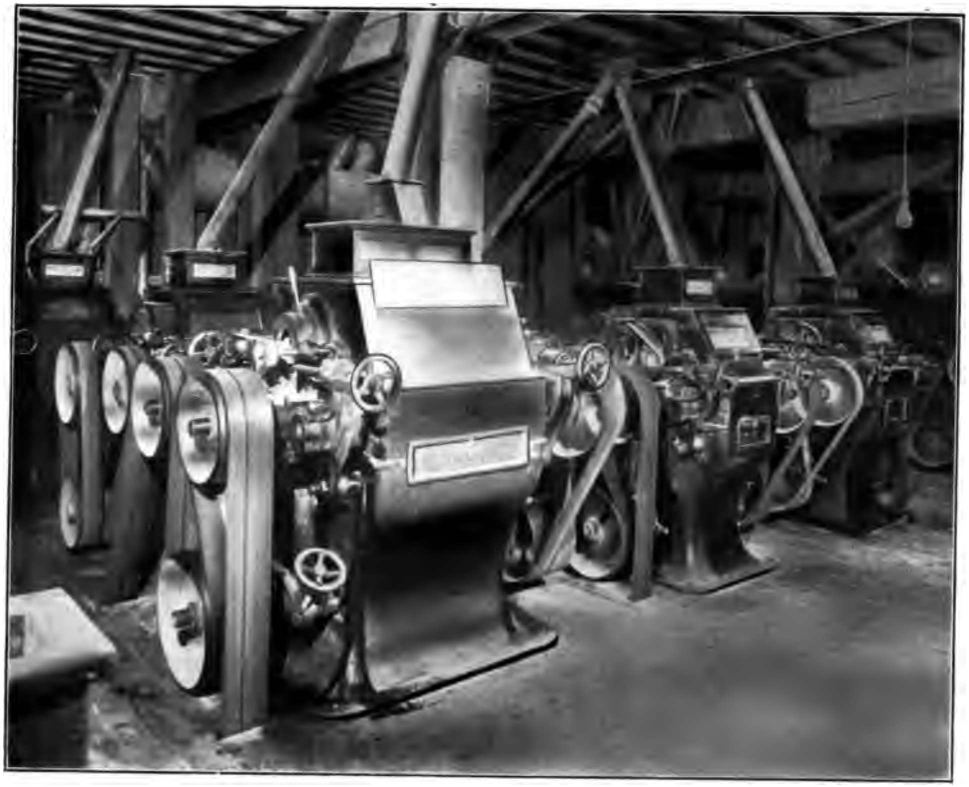


Photo from the Washburn-Crosby Co., Minneapolis, Minn.
MODERN MACHINES FOR MAKING FLOUR BY THE ROLLER PROCESS.

MILLS AND FACTORIES.

The manufacturing interests of the region are many and important. When the country was first settled lumber mills and flour mills were erected at almost every place where there was a convenient water power. These early mills were usually small and were built to supply the local needs. As the country gradually filled up, and the population grew denser, both the lumber trade and the flour trade became more specialized, and large mills were built where they could advantageously get a supply of logs or grain. Thus the great lumber mills were located mostly on the Mississippi River and its northern tributaries, because nearly all of the logs used came from the pineries in the north.

The early flour mills were small and numerous, because they must be within reach of the farmer who raised the necessary grain and who had to haul the same to the mill to be ground. But in recent years many farmers do not raise any wheat at all, finding it more profitable to devote their land to the cultivation of corn and to stock-raising, buying their flour and leaving the raising of wheat to the farmers of Dakota and Minnesota. This specialization in wheat raising resulted in large flour mills being built at convenient points. These points are usually at places where there is great water power. Thus, about the Falls of St. Anthony a great flour industry grew up, and in connection therewith the city of Minneapolis. The Falls of St. Anthony afford a tremendous water power. Minnesota and North and South Dakota furnish unlimited quantities of wheat.

There are other cereal industries in the region beside that of flour. The making of oat-meal is carried on extensively at Cedar Rapids and Muscatine, Ia. There are also glucose factories which utilize large quantities of corn.

The making of farm machinery has long been one of the leading industries of the region, in the development of which different cities have specialized along different lines of implements. Thus Moline, Ill., has long been famous for its plows, cultivators and wagons. At Minneapolis, Minn., there is a large factory which turns out thrashing machines. Sandwich, Ill., is noted for its wind-mills and Plano for its harvesters. Burlington, Ia., makes large numbers of wagons which are shipped not only to the immediate region, but generally throughout the west.

The manufacture of building material of different kinds is rapidly developing. There are cement works at Hannibal, Mo., in which more than $1,000,000 is invested. This plant makes 1,500,000 barrels of cement annually. There are also extensive cement works at Mason City and Ft. Dodge, Ia. All these places are located where suitable shale and limestone abound in close proximity.

The making of paving and building brick is another important industry. Galesburg, Ill., is one of the leading centers. The kilns at this place turn out more than 100,000,000 bricks per year. There are also extensive kilns at Des Moines, Oskaloosa and Burlington, Ia. Like the cement works, the brick kilns are located where the necessary materials occur near together.

There are a number of large potteries and many tile factories. Among the largest and best known of the potteries are those at Monmouth and Macomb, Ill. At Monmouth the clay, or rather the shale used, is brought up through shafts from many feet underground. The pottery manufactured is largely of ordinary grade, although some attention is paid to the finer ware. The products of these factories are shipped all over the country.

Photo from Monmouth Mining and Manufacturing Co.
TILE FACTORY OF THE MONMOUTH MINING AND MANUFACTURING CO., MONMOUTH, ILL.
The large tiling piled up in the foreground is vitrified ware, made especially for sewers and culverts.

Photo from the Iowa State College of Agriculture and Mechanics Art.

LAYING TILE FOR DRAINING LAND THAT IS TOO WET. The tile is porous, which with loosely fitting ends of the joints, permits the water to find its way into the pipe easily.

The tile factories are numerous and scattered widely over the region. Much tile is used in draining farm lands. Being needed in large quantities, this kind of tile must be sold cheaply. As it is porous, it can be made out of surface clay, which is usually abundant, and easily and cheaply worked. The drain tile does not stand much handling, and it is fortunate that suitable clay is so generally found, thus permitting the establishing of tile kilns and yards in the immediate vicinity where there is a demand for cheap tile.

Sewer tile must be water-tight, and requires for its making the same quality of material as that used for paving brick. Like paving brick it can be shipped a long distance and handled without much danger of breakage. The factories where it is made are not so numerous. Some of the best known are at Monmouth, Ill.

Furniture is manufactured in many different places, but Rockford, Ill., probably makes more than any other city in the region. A large part of the better grade of furniture is made of oak, of which more particular mention is made elsewhere. Formerly, much of the oak lumber came from the states of the Upper Mississippi Region and adjoining states, Indiana, among others, furnishing large quantities. But the supply in these states is so nearly exhausted that Arkansas, Tennessee and other southern states are now furnishing most of it. More concerning the woods used in making furniture is given in that part of this chapter which deals with the forests of the region.

Among the special industries which have grown up within recent years, the pearl button business is deserving of notice. When it was discovered that the clam shells of the Upper Mississippi River made excellent buttons, and that they could be gathered

Photo from the Washburn-Crosby Co., Minneapolis, Minn.

BARRELS GOING INTO THE MILL TO BE FILLED WITH FLOUR.

The rack on the wagon will hold 150 empty barrels. When they are filled with flour each barrel will contain 196 pounds.

cheaply and in large quantities, many factories immediately sprang up. In making pearl buttons, "blanks" or disks are first cut from the rough shell. A large part of this work is done at small factories scattered along the river. The "blanks" are then taken to larger factories where the finishing is done. In order to cheapen the manufacture, highly specialized machines have been invented. A single person with one of these machines can do the work which formerly required the services of four or five persons. The business was first developed at Muscatine, Ia., and that city still remains the center of the manufacture and trade.

In this brief survey it has not been possible to speak of all the natural wealth of the region and to mention every line of industry that is worthy of note. Nor in treating of any particular industry has there been any attempt made to name all the places where it is carried on. The thought has been to give a general idea of the resources and to show how they have been made use of to man's advantage.

A STEAMBOAT RACE ON THE MISSISSIPPI.

IV.

THE MISSISSIPPI RIVER FROM ST. LOUIS TO MINNEAPOLIS.

Steamboats ply on the Mississippi as far north as St. Paul. About ten miles above the landing at St. Paul occur the Falls of St. Anthony, around which is built the city of Minneapolis. By deepening the channel along this ten-mile stretch, steamboats could go as far as that city. This improvement, which has been frequently talked of but never undertaken, would make Minneapolis the northern terminus, instead of St. Paul. On account of the Falls of St. Anthony, steamboats could go no further north.

There are some steamboats on the Mississippi above Minneapolis, but they are small and of lighter draft. For the most part they are engaged in rafting.

Although steamboats can go from St. Paul to the Gulf of Mexico, there are none which regularly make this trip. St. Louis is the division point between the traffic on the upper river and the lower river. Above St. Louis, during a time of low water, steamboats must not have a draft much over three feet, while on the lower river they may draw six feet.

There are steamboats which regularly make the round trip between St. Louis and St. Paul about once in ten days for four or five months of the year, running until along late in September or early in October. In order to keep the channel of sufficient depth, the government has built hundreds of wing dams extending from the shores and islands far out into the stream. These dams confine the current to a certain place and the constant scouring keeps the channel open. The sand thus scoured out is thrown into the stiller water behind the dams, where it settles. During flood time more sand and silt lodge there, and by and by the deposit is built up to the top of the dam. In many places there are a number of the wing dams, one after another, a quarter of a mile or so apart and each extending outward from the shore that distance or farther. The shore line is thus extended far out into the river and the channel is confined more permanently to one place.

But with all the work the government is doing to keep the channel deep enough, frequently, at the time of low water during August and September, steamboats find difficulty in making the passage, on account of the sandbars which form and extend across the river where the current is not very swift. When the water is falling very rapidly, one of these bars may form in a single day. During extreme low water it takes a skillful pilot to guide the steamboat, and he must be constantly studying the changes that are taking place in the channel.

Let us take a trip from St. Louis to St. Paul by one of the regular packets. We find the river wandering southward in a valley several miles in width, running now in the middle, now on one side, and again striking diagonally across. Where it runs close under the bluff bordering the valley, there are nearly always perpendicular rock cliffs, as at Hannibal, Mo., Quincy, Ill., and Burlington, Iowa. In such cases the other bluff will be several miles away, with a somewhat gradual slope, and covered with a mantle of soil. On the

FARM YARD ON THE MISSISSIPPI FLOOD PLAIN DURING EXTREMELY HIGH WATER.

lowland between there is a forest of elm, soft maple, ash, cottonwood, sycamore, and other trees of lowland growth. Where the river runs midway of the valley both shores are lined with the lowland forest, and the bluffs present but few bold rock exposures. The higher sand-bars and the recently-made land are covered with a dense growth of willows.

If we make the trip as early as May or June we shall probably see the lowlands flooded and the river quite generally several miles in width. In some places at the time of the highest flood the river extends from bluff to bluff. Then it is truly a majestic stream. At such a time the water is heavily charged with silt which is brought down from the uplands by tributary streams. The water flowing less swiftly over the submerged lowlands, the silt is constantly deposited. Thus the lowlands are being continually built up, and in the course of time there are places that are out of reach of any ordinary flood. As previously mentioned, this lowland soil is exceedingly rich, and we notice in a few places where there is a considerable area of it that high embankments, or levees, have been built to keep out the floods. There is an extensive levee just below Quincy on the Illinois side, and another, twenty-five miles long, above Burlington on the Iowa side.

We have scarcely left the wharf at St. Louis before our boat is passing under the great Eads bridge that spans the river between St. Louis and East St. Louis in Illinois. There is an immense traffic over the great bridge, which has two floors, one for railways and the other for street cars, wagons and pedestrians. Two miles further up stream is the Merchants' bridge, not so great a structure as the Eads bridge, but still one over which there is a large amount of traffic.

A couple of hours' steaming takes us past the mouth of the Missouri.

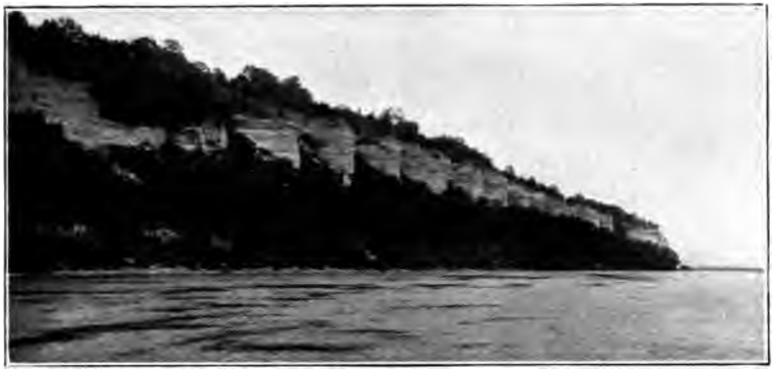


Photo by W. L. Hanson.
THE LIMESTONE BLUFF NEAR ALTON, ILL.

Where its water unites with that of the Mississippi we notice the difference in color. Excepting during the time of low water, the Missouri carries much more silt than the Mississippi and as a result its flood is so thick and dark with mud that a sharp line seems to separate it from the water of the Mississippi, and they flow on for many miles before they mingle.

The combined flood plain of the Mississippi and Missouri at their junction is many miles wide and contains thousands of acres of the richest land in the state of Missouri. The region is given over largely to the raising of corn and wheat. The soil, however, is especially adapted to gardening and that industry is on the increase. If we were coming down the river in the late summer, our boat might possibly stop somewhere along the bank and take on a cargo of wheat which had just been threshed in the nearby fields. The grain is usually in two-bushel sacks which are slid down from the high bank on a long chute to the lower deck, where they are piled up in long rows.

A short distance above the mouth of the Missouri river we pass Alton, Ill. Near the city there are high limestone cliffs, striking in their appearance on account of the regularity with which they have broken away along the jointings, leaving a great wall with regular offsets. The river runs close to the base of this high cliff. A couple of hours steaming from Alton brings us to the mouth of the Illinois river which adds a large volume of water to the Mississippi. Proceeding northward, a number of towns of considerable importance are passed on the Missouri side.

Three or four miles below Hannibal there are immense cement works. Just in the southern edge of the town itself we see the high cliff known as "Lover's Leap," one of the highest points along the river between St. Louis and Dubuque. Hannibal and vicinity are interesting on account of being the region where Mark Twain's well known stories of Tom Sawyer and Huckleberry Finn were laid. Twenty miles above Hannibal is Quincy, Ill., where again there are high rocky bluffs.

At all the towns so far mentioned there are railway bridges across the Mississippi, as there are at many of the towns which lie further up. Nearly all these bridges have draws which swing on a central pivot to permit the steamboats passing up and down the river. Some thirty miles above Quincy on the Illinois shore is Warsaw, one of the oldest towns of western Illinois. It also occupies a high rocky bluff.

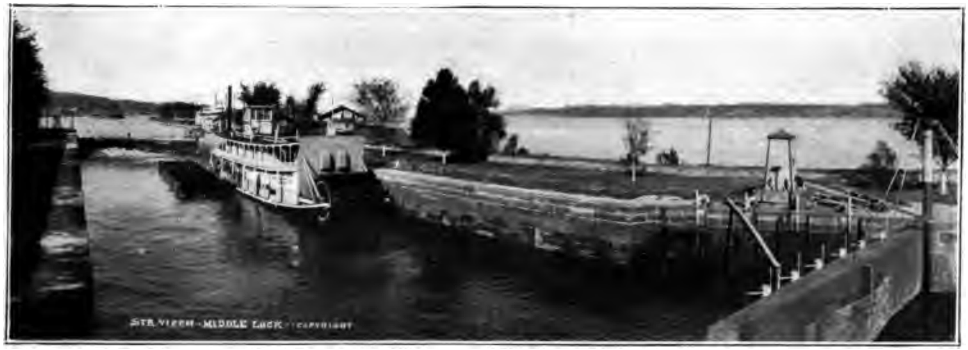


Photo by Anschutz.

THE MIDDLE LOCK IN THE CANAL AROUND THE LOWER RAPIDS OF THE MISSISSIPPI.

The steamboat has entered the lock from the lower end. The lower gates are just closing, the one on the right showing in the picture. The upper gates are still closed. As soon as the lower gates are closed, water will be let into the lock and when the water in the lock is on a level with that above, the upper gates will open and the steamboat can pass on up. Note the river on the right distance.

Nearly opposite Warsaw the Des Moines river comes in from the northwest.

Two or three miles above the Forks of the Des Moines and Mississippi is Keokuk, Ia., which is situated at the foot of the Lower Rapids of the Mississippi. These rapids extend for nearly ten miles, and during low water steamboats must use the canal, which is built on the Iowa side, to pass around them. The valley of the river is here not more than three-quarters of a mile wide and is bordered by high rocky walls which makes this stretch of the river a true gorge. Preparations are now being made to erect a dam at the lower end of the rapids which will furnish water power of much greater capacity than that now being used at Niagara Falls. There are three locks in the canal leading around the rapids. These are large enough to permit log and lumber rafts to be taken through in sections. One of the locks is at the lower end of the canal, one near the middle and the other at the upper end, and they are known as the Lower, Middle and Upper Locks.

Just above the rapids is Nauvoo, Ill., noted as being the seat of the Mormon Church from 1839 to 1847. There remains in the town very little of what belonged to the Mormons. The fine temple they built was long ago torn down and the stones used in

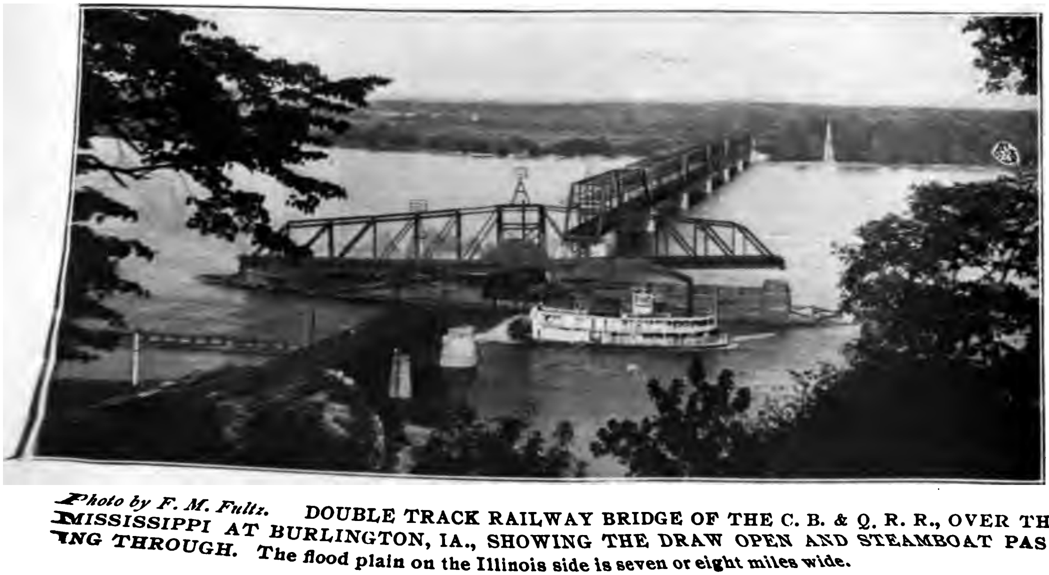


Photo by F. M. Fultz. DOUBLE TRACK RAILWAY BRIDGE OF THE C. B. & Q. R. R., OVER THE MISSISSIPPI AT BURLINGTON, IA., SHOWING THE DRAW OPEN AND STEAMBOAT PASSING THROUGH. The flood plain on the Illinois side is seven or eight miles wide.

building other structures. Nauvoo stands on a commanding hill and in its midst there is a large Catholic church with tall spire which is easily seen for ten miles up the river. The hills about Nauvoo are covered with vineyards.

Ten miles further up the river we pass Ft. Madison, the earliest of the government posts established in the region now occupied by Iowa. Just below Ft. Madison, and also a few miles above the town on the Iowa side, there are extensive flood plains which for the most part lie above present high water. The sandy and alluvial soil of these flood plains furnish fields for the cultivation of melons, sweet potatoes and vegetables of all kinds.

Forty miles north of Keokuk we pass Burlington, the first capital of the territory of Iowa. In the early days of settlement this place was known as "Flint Hills" on account of the white deposits of flint which everywhere show along the face of the high rocky cliffs.

At Burlington the channel of the river is on the west side and for some distance below the city it flows close under a high rocky bluff. The business part of the city is built on the floor of a little valley that comes in from the west. As we approach the city from the south along the base of the high rocky bluff already spoken of, we pass through the draw of the double-tracked bridge of the C. B. & Q. Railway. Just above the bridge is one of the few remaining saw mills along the course of the Upper Mississippi. Extending along the shore for some distance above the mill is the boom, full of logs which have been brought from the pineries. Half a mile from the bridge we steam up to the levee, which is similar to those of the other towns we have passed further south. The levee is paved with stone blocks from above the point of high water down to low water mark, and even extending out some distance further. The slope is gradual, so that heavy loads may be hauled up from the barges and boats at the landing and from the warehouses which are built on high foundations near where the edge of the river is at the time of low water.

We find at the wharfs the smaller packets which are engaged in trade between local points. There are many of

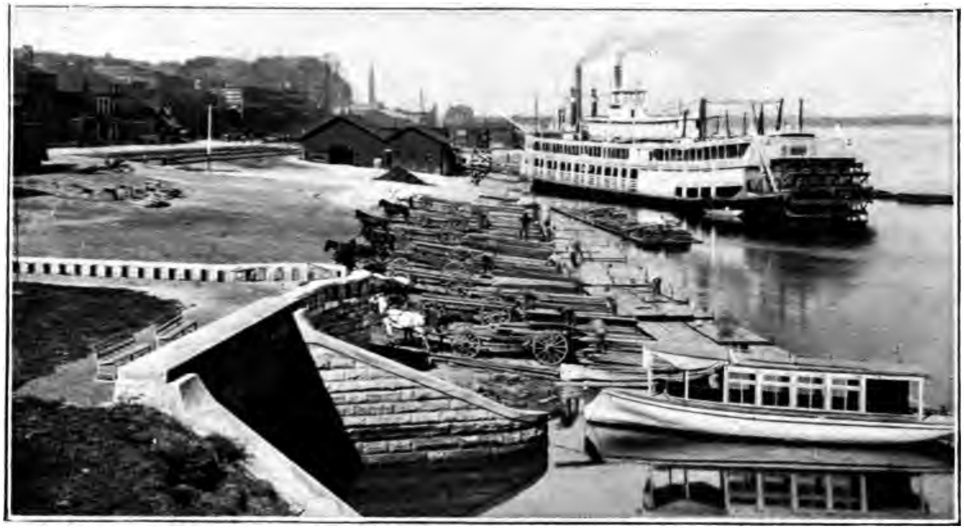


Photo by Ernest Hanson. LEVEE AT BURLINGTON, IA.

Note the "Pulling" of lumber going on. These lumber rafts have been floated down the river from the sawmills near the pineries in Minnesota and Wisconsin.

these smaller steamboats engaged in local trade between points on the upper river. At Burlington we find some which have Davenport as their northern terminus and others which go as far south as Keokuk. When three or four of these boats are at the levee at the same time, a lively scene is presented in the unloading and loading of freight, and the passing to and fro of passengers over the gang planks. There is likely to be something of a crowd at the levee to watch the arrival and departure of the steamers. While steamboat racing is not carried on to the extent it was in the earlier years of the river traffic, yet occasionally one sees a friendly strife of this character.

In this vicinity we see many clam fishers at work. For the most part they use small flat-bottomed boats and fish for the clams with dredges of various descriptions. The clams are gathered for the shells which are used in the making of pearl buttons.

Just above Burlington the flood

Photo by Harry E. Wood
ROUSTABOUTS LOADING FREIGHT.

plain of the Mississippi is wider than we shall see it again at any point further north. For some distance the river runs about midway of the valley, leaving four or five miles of flood plain on either side. The river itself is cut up into many channels, forming innumerable islands, which when viewed from the high bluff at Burlington, present a picturesque and pleasing scene. About fifty miles north of Burlington, we come to Muscatine. Just below the city there is an old flood plain known as Muscatine Island. Part of it is above reach of high water, and the balance of it is protected by a levee. The place is famous for its watermelons and sweet potatoes. Muscatine was formerly a lumber center, there being four large mills in operation; but the decline of the business has made it necessary to close them all permanently. The principal industry of the town is the making of pearl buttons.

Twenty-five miles further up the river are situated the Tri-Cities, Davenport, Ia.. and Rock Island and Moline, Ill. There are nearly 100,000 people in the three cities. Here also is the Island of Rock Island, which is owned by the national government and upon which is situated the Rock Island U. S. Arsenal, one of the largest of the government arsenals. Between the Island and the Iowa shore are the Upper Rapids of the Mississippi which also extend several miles above the upper end of the Island. These rapids are not so shallow nor so swift as the Lower Rapids at Keokuk, and by blasting out the rock bottom, a channel has been made deep enough for the passage of steamboats. However, special pilots are required to take boats up and down the rapids.

A large force of skilled mechanics are constantly employed in the various shops of the arsenal and great quantities of rifles and army supplies of various kinds are turned out.

On the island is situated the house of Colonel Geo. Davenport, built in 1833. It was in this house that he was murdered July 4, 1845. The house is kept in repair, although not occupied. From the deck of the steamboat, just as we pass through the draw of the big bridge connecting the Island with Davenport, we may see the old Davenport house. It is situated close to the bank of the river and is not hidden by many trees.

Just below Rock Island the Rock river empties into the Mississippi. It occupies a valley much too large to have been formed by so small a river, and which it is believed was in the distant past the bed of the Mississippi. The alluvial soil in this Rock river valley is very rich and at one time was the favorite corn field of the Sacs and Foxes, the Indians who were occupying this region when the white men came. The region on both sides of the river for a hundred miles both north and south of Rock Island was the particular hunting ground of the Sacs and Foxes and it was to keep posession of this that Chief Black Hawk fought in the conflict known as the Black Hawk War.

Photo by W. W. Atwood.
ROCK CHIMNEYS NEAR THE MISSISSIPPI IN THE DRIFTLESS AREA OF WISCONSIN.

After passing Davenport, the valley of the river is materially narrower and there are no great flood plains, such as those near Quincy and Burlington.

As we proceed northward we pass a number of towns of importance: Clinton, Ia., at one time one of the greatest lumber centers on the Upper Missis-

Photo by Natchtrieb. VIEW ON LAKE PEPIN
Note that the river fills the valley from bluff to bluff.

sippi; Dubuque, Ia., named after Julian Dubuque, who mined lead there as early as 1788; LaCrosse, Wis.; Winona and Red Wing, Minnesota, and other towns of lesser size.

About half way between Prairie du Chien, in the southwest corner of Wisconsin, and LaCrosse, some fifty miles further north, on the east bank of the river, is the scene of the battle of Bad Axe. It is here that Black Hawk met his final defeat. The battle took its name from the river of Bad Axe, a small stream which joins the Mississippi at this point.

In our trip up the river, we notice that wherever tributary streams come in, the valleys are cut down very nearly to the level of the river valley and that many of the principal cities are located at such points, the business blocks being on the low ground, and the residences occupying the surrounding hills where there are commanding views of the river.

Near the north boundary of Iowa the bluffs rise higher, while the valley grows much narrower and looks like a deep trough. This is in the Driftless Area and we notice, especially on the

Wisconsin side, the rock pinnacles and towers which show that the glacier never moved over these hills. Many of the rocks are sandstone, (frequently stained with a variety of colors), that erode easily, and which furnish much sand for the river to carry southward. There is considerable limestone, too, some of which is weathered and sculptured into grotesque forms.

A short distance further north, we pass through Lake Pepin, which is simply a portion of the Mississippi river twenty miles long and two to four miles wide, where the current is slack and the water deep. The lake is caused by the Chippewa river which flows into the Mississippi on the Wisconsin side. The detritus carried down by the Chippewa has so silted up the channel of the Mississippi that its bed has been raised many feet, thus damming back the water and forming Lake Pepin. The lake occupies the full width of the valley, extending to the bluff on either side. It is a dangerous stretch of water for steamboats during wind storms.

The head of navigation is at St. Paul. If we wish to see the river further north, we may take a small excursion boat as far as the mouth of Minnehaha Creek, which is about four miles above St. Paul. A short distance before Minnehaha Creek is reached, we pass Ft. Snelling, which is on the west bank of the river and on a high bluff. From Minneapolis to Ft. Snelling, a distance of about seven miles, the Mississippi flows through a deep, narrow gorge which has been cut since the great glacier occupied this region. The gorge begins at the Falls of St. Anthony and ends at Ft. Snelling. Its formation was comparatively easy on account of the hard limestone layers at the top being underlaid by the easily eroded St. Peter's sandstone. At one time the Falls of St. Anthony were near where Ft. Snelling now is. After the Glacial Period, the river, some eight miles further north, found its valley filled with drift and was forced to take a new course. It flowed across the upland and dropped for nearly 100 feet into its old valley. The falling water rapidly cut away the soft sandstones at the base, and the limestone layers at the top, left unsupported, fell away in great masses. The Falls of St. Anthony are noticeably further up

Photo by Harry E. Wood.
MINNEHAHA FALLS.

the river than they were when first seen by white men in 1680.

Minnehaha creek has likewise cut back a narrower gorge from the Mississippi to the distance of nearly half a mile to where Minnehaha Falls now are. The soft St. Peter's sandstone shows along the walls of Minnehaha gorge, and before the place was made a public park and protected from vandalism, tourists were accustomed to dig out sand of various colors from the sides of the gorge which they filled into bottles so as to make pictures or other pleasing effects with variegated bands.

St. Paul is located where it is, because in the earlier days of settlement the head of navigation on the Mississippi was a much more important thing than a great water power. But as soon as the country was settled up and mills had to be built, people began to make use of the great water power of the Falls of St. Anthony, and on account of the manufacturing the water power made possible, the city of Minneapolis, which grew up around it, soon surpassed St. Paul in size and importance.

The flour mills in Minneapolis are the most extensive in the world, and are largely driven by the power furnished by the Falls. The place is also one of the chief lumbering points of the north. Above the Falls there are extensive log booms, where the logs floated down the river from the forests surrounding its headwaters are collected. A mile or so below the Falls there are several large saw-mills, at each of which there is a smaller boom from which the logs are taken up long inclines into the mill. The logs cannot be brought over the Falls in rafts, but are floated singly through plank chutes. Beside the logs used at the Minneapolis mills there are thousands of others sent down the chutes. These float through the gorge and are collected into booms near Ft. Snelling, where they are sorted and made into rafts.

The whole face of St. Anthony Falls has been covered with a frame of heavy timbers and planked over in order to prevent any further wear of the rocks by the water and thus preserve the water power.

The scenery around St. Paul and Minneapolis is interesting and furnishes several days' pleasant and profitable sight-seeing. The Falls and Gorge of Minnehaha are about midway between the two cities. Everyone, too, should see the fine view of the Mississippi's gorge which may be had from the high bridge at Ft. Snelling. Also, from this bridge one may watch the sorting of logs in the river below. Ft. Snelling itself is a point of interest, although no longer of the importance it was when the country was new and the peace and security of the region depended upon the soldiers who were stationed there.

There are numerous lakes in the region, a number of which are within the city limits. Around some of them city parks have been established and beautiful driveways constructed. Lake Harriet is one of these. But the lake of special charm and interest is Minnetonka, situated about twenty miles west of Minneapolis. This is one of the most famous northern summer resorts and thousands of people from further south spend some portion of the hot summer months around its shores.

V.

AN IOWA COAL MINE.

The coal fields of Iowa extend over nearly one-fourth of the state. The area is V-shaped, with the angle of the V pointing to the north and reaching to about Ft. Dodge. The open part of the V is on the southern boundary of the state, and extends from about seventy-five miles from the eastern end of the boundary to about the same distance from the western end.

This coal area extends through the state of Missouri, southeastern Kansas, Oklahoma and on into Texas, and is one of the largest single coal areas in the world.

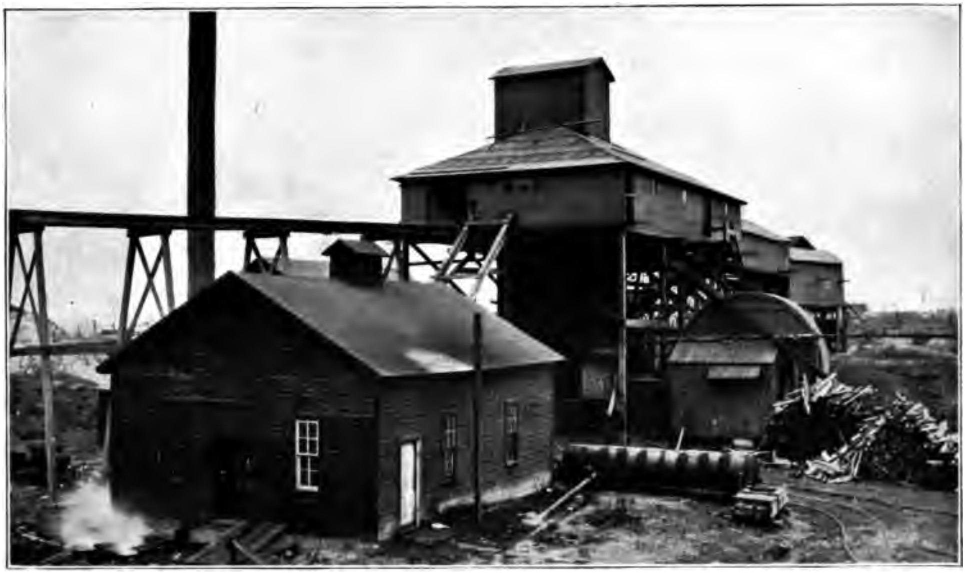
Within the V-shaped area in Iowa, many mines have been opened and thousands of tons of coal are daily being taken out. Some of the prosperous towns of southern-central Iowa owe their being and prosperity largely to the coal industry. Centerville is one of these cities. More than one thousand men are employed in the mines situated in the near vicinity. A number of these mines are within the corporate limits of the town. Some of them are operated on a very small scale, no machinery being used, employing only a miner or two and putting out but a few tons per day, while others use a large amount of machinery, employ hundreds of men and put out from two thousand to three thousand tons per day. It is of one of these larger mines that I shall attempt to give you a description.

The mine in question is known as Relay Mine, No. 3, of the Centerville Block Coal Co. A large part of the machinery is above ground and can be easily seen and understood. At a first view of the upper works, one wonders why so many buildings are necessary; but an examination shows that each has its separate use in the economy of running a large coal mine. Of course the most prominent of the buildings is that which contains the upper works of the shaft, the sheds for weighing and the bins for storing the coal. Other buildings clustered around are for hoisting machinery, compressing air for use in the mines below, for the fan by which the mines are ventilated, for repairing tools, etc. A glance into each of these buildings will show the machinery within in operation and performing its share of the work that goes to make the operation of a large coal mine an economical success.

In one of the buildings is an engine operating an endless steel cable which runs out of the building down the shaft and along the main gallery of the mine for twenty-five hundred feet, hauling coal cars to and from the foot of the shaft. Another engine in this same building is used in compressing air which is carried in iron pipes to the remotest galleries of the mine, in some places nearly a mile away, where it is used to drive mining machines which are each doing the work of several men. In another building is an engine which is operating the elevators in the shaft, the cages of which bring up at once two coal cars of three tons each. Still another engine is driving the fan which occupies a large circular box about twelve feet in diameter, and which keeps a current of fresh air constantly circulating through the mine.

From the top of the shaft running in the opposite direction from the weighing and storage sheds is a trestle which runs out to the dump. Along this trestle is piled the refuse material brought up from the mines for which no space could be found in the mined-out portions of the mine. Most of the refuse is left down in the worked-out galleries of the mine and it is only occasionally that a car-load comes up the shaft along with the coal; and one watching the operations and seeing the comparatively small amount of waste thus brought up wonders that such a great mass of it is found along the dump; but it is a constant process, and while a comparatively small amount is brought up, yet the accumulation goes on day after day, and year after year.

The sinking of a shaft is one of the chief expenses in the opening of a coal mine. The hole required for a shaft is usually not less than twenty by twelve feet. It is sunken straight down into the earth and must be walled with heavy timbers until the solid rock is reached, in order that the earth may not cave in. When the rock is reached, blasting is required and the expense of carrying a shaft downward is thereby much increased, but at the same time such heavy walls of timber are not needed, as the wall of rock will support itself. The shaft is usually di-



THE UPPER WORKS OF RELAY MINE NO. 3, CENTERVILLE, IA.

The house in the foreground contains the hoisting engines. The shaft is in the center. The drum-like structure on the right is the fan which ventilates the mine. The trestle running to the left is for carrying away the refuse. The end of the dump pile shows just beyond the trestle. The weighing and storage sheds are beyond the shaft.

vided into several compartments, two of which, usually about eight by ten feet, are used for the carriage ways, for hoisting the coal and taking down workmen and material into the mine. Besides these elevator ways there are passages for the air-ducts and for the operation of the pumps which keep the mine drained of water. The elevators used for hoisting the coal and lowering the workmen into the mine are stoutly built, but of simple construction, being merely a heavy frame with a stout plank floor. There is usually no rail protection around the platform, as such railing would interfere with the rapid handling of the coal-cars which are being continually brought up loaded with the full cars and taken down with the empty cars. The shaft extends some distance above the surface in order that the coal may be hoisted up to the high platform where the weighing scales are, and from where it can be easily dumped into the storage bins, these storage bins themselves being high enough for gates to be opened in the bottom or along the sides and allow the coal to drop into railway cars run immediately beneath.

Let us get into one of the elevator carriages and go down into the mine. It will be dark down there. We must each of us put on a miner's cap, to the front of which is attached a little lamp. We had better put on a pair of miner's over-alls and a blouse, too, for we shall rub against black walls. It will be well, also, to put on a pair of heavy shoes, for we shall have to walk in some places where the floor is wet and slippery from constantly dripping water. We step onto the car, the guide pulls a signal rope, the drum on the hoisting machine begins to turn and down we go into utter darkness. The irregular movements of the car give something of a feeling of uneasiness and a sensation of the lack of stability to our carriage. We look upward and see the light rapidly changing to a mere patch of haze, for the roof of the elevator shaft does not permit a clear view of the sky; but we have hardly time to realize what our sensations are before the car comes to a stop at the foot of the shaft. The shaft of this mine is only a little more than a hundred feet deep.

The light from our little lamps enables us to see a passage extending away from the foot of the shaft. We step out of the elevator carriage and dimly make out a large room filled with loaded and empty cars, the loaded ones waiting to be taken up the shaft and the empty ones ready to be made into a train to be carried back into the mine. Two or three men are busy handling the cars. A train of about twenty of the empties is made up, we are told to get into the rear car and to squat down as low as possible so as to avoid hitting our heads against the roof of the passage. The box on one of these coal cars is about three feet wide, six feet long and fifteen inches deep, with flaring sides to enable the coal to be piled to better advantage. A car will hold about three tons of coal.

The endless cable previously spoken of in connection with the upper works of the mine, runs along this main passage for twenty-five hundred feet, or about half a mile. The train of empty cars is attached to this cable, a signal is given and away we go into the depths of the mine. We are whisked along at a pretty rapid pace, and as the track is none too level and the cars only loosely coupled together, most of our attention is occupied in trying to keep our position in the car and in watching that our heads do not come in contact with any projections from the roof. However, we note that the sides are very irregular and that the roof is everywhere black and sometimes shining from the moisture collected there.

When our train of cars stops at the end of a half mile, we get out of our car and watch the operations going on. The passage is somewhat wider here, and there are two or three sidings to the track. The train of cars is quickly cut up into sections of about six cars each. Soon a light is seen coming down the passage from the further depths of the mine, accompanied by the noise of rumbling cars and the cries of a driver trying to urge on the mule which is pulling the cars, for beyond where the cable is operated mules are used to haul the cars. The loaded cars are quickly run onto a siding, the mule unhitched, turned around and quickly again hitched to a half dozen empties, in the rear one of which we take our places, and again we are going on into the depths of the earth. If the ride on the car when attached to the cable was exciting, the one behind the mule was doubly so, for beside the uneven track and jerking caused by the poor coupling, the sudden slacking up or starting forward of the mule added an alarming uncertainty to our position in the car. Every now and then our guide yells to us to duck our heads and to hold on to our caps, and almost instantly afterward we feel a great flap of canvas drag over us. This canvas flap is a curtain to shut off the passage of air along the main gallery and make it pass through other galleries in order that the air everywhere may be kept in circulation. A half mile ride behind the mule brings us to where the miners are at work. We are now nearly a mile away from the shaft.

We find the miners at work in a number of rooms. Machinery is here largely used, although a few miners are working singly with pick and crowbar after the old method. The machines are operated by compressed air brought in through iron pipes from the compressing pump at the top of the shaft a mile away. The rooms where the coal is being taken out are from nine to fifteen feet wide. A Jaffrey machine is first run into the end of the room. This machine operates a rapidly revolving cylinder of a few inches in diameter, armed with chisel teeth. This cylinder cuts away the shale immediately beneath the coal to a distance of about four or five feet and for three feet in width. The machine is backed off, shoved sidewise the length of the cylinder, another three-foot strip similarly cut out, and so on for the full width of the room. The Jaffrey machine is then backed out of the passage and taken to another room, while another machine, known as the Harris machine, is brought in. This machine is likewise run by compressed air and operates a huge drill-like chisel. This chisel cuts a perpendicular channel in the wall of coal on the sides of the room from the floor to the roof. This machine is then backed out of the passage and follows up the Jaffrey machine wherever it has gone. In the end of the room there is now a huge block of coal loose at the bottom and on the two sides, but still remaining attached to the roof and behind. Now the miners come and with crow-bar and pick soon have a great mass of coal ready for the cars.. The tracks are kept laid close up to where the coal is being taken out and a crew of common laborers pile the loosened coal into the cars. The miner then attaches his individual tag to the car and it is run out into the main gallery, where along with four or five others it is hauled by a mule to the endless cable and thence to the shaft. The weigher at the top of the shaft weighs the car and by means of the tag which the miner has attached gives due credit to the man who mined the coal; for the miners work at so much per ton.

The continual hammering of the compressed air engines, the tapping of the drills and the escaping of the air, combined with the darkness and the clouds of dust that make the lights on the miners' caps hazy and indistinct, produces a scene that is weird, and one not soon to be forgotten.

The coal bed in this mine is about three feet thick. A bed of this thickness is, as a rule, not so easily worked as one of greater depth, because the main passage must be deepened in order to allow of a free and rapid transportation of the coal to the shaft; but sometimes, also, as happens in this mine, the roof is of such character that there is very little falling of rock material from above and on that account very little propping is needed. Props are frequently an item of considerable expense, and it is not unusual to have to prop continuously throughout the main passage. In the main passage the propping is usually done by placing an upright post on either side, and across them, supporting the roof, a heavy beam. In the room where the coal is being taken out and where props are necessary, they are merely an upright post with a flat wedge driven in between the top and the roof.

There is always more or less falling of rock material from the roof, even in mines where the roof is composed of harder, more compact rock. The rock forming the roof is usually a sand-stone or a compact shale called by the miners "slate." The rock forming the floor is generally a softer shale containing a good deal of carbon.

Nothing has been yet said about the relation of the main passages or galleries to the various side passages and rooms. Of course the first passage that is cut away from the foot of the shaft is the main gallery along which the track is laid. This is usually carried to a considerable distance before any other passages are made. Next a cross-head is made close to the shaft at right angles to the main gallery. This cross-head is extended forty or fifty feet, then another passage is run parallel to the main gallery and the coal worked out from either side. There are frequent passages made between these parallel passages and the main gallery, but there is left a continuous pier of coal on either side of the main gallery which acts to sustain the roof. As the galleries are extended further and further away from the foot of the shaft the openings to the cross-heads nearest the shaft are closed up, so that in time, as the coal is mined out in the vicinity of the shaft, the main gallery becomes a continuous, unbroken passage.

The coal seams do not usually lie on a perfect level, so that in passing along the main gallery we are sometimes going up hill and sometimes down hill.

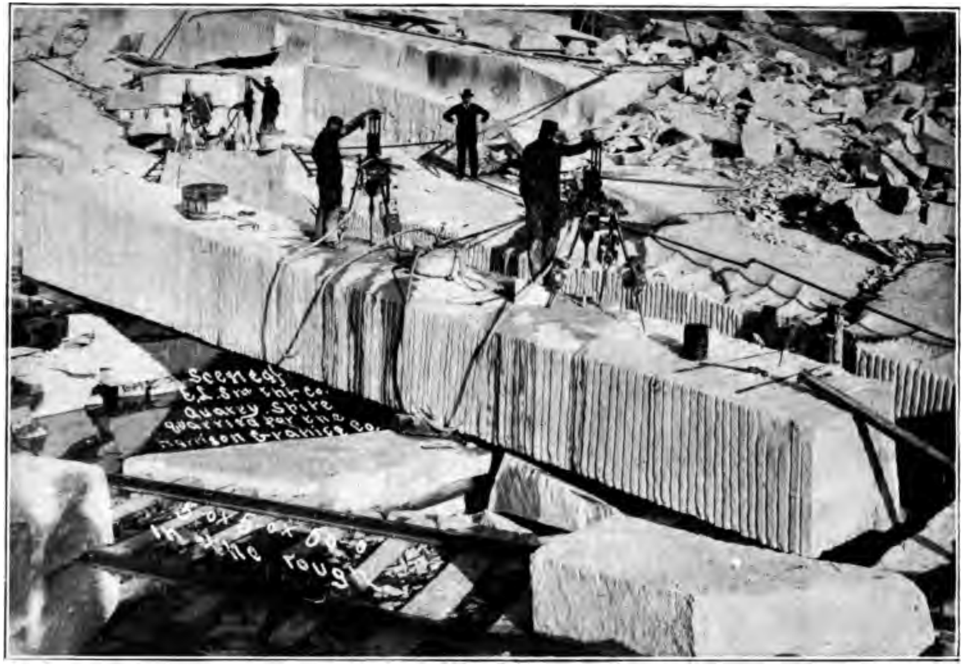
On this account the water which finds its way into the mine collects in different parts and it becomes necessary to run pipes in order that it may be pumped out. The temperature in a mine varies but little throughout the year.

There are many dangers connected with coal-mining. There is always the danger of rock material falling from the roof, and always more or less danger from fire. Sometimes the upper works of the mine take fire and the hoisting machinery is damaged or destroyed so that no means are left for bringing up the workmen from below. Sometimes the fire follows down the casing of a shaft and even into the mine, thus shutting off all possibility of escape through the shaft. The laws of some states provide againt this danger by requiring at least two shafts to each mine. Then there is danger from explosion of fire-damp and from poisonous gases collecting where the ventilation is not properly cared for. Sometimes also the mine is suddenly flooded by the breaking of walls which separate rooms or passages from old abandoned portions of the mine. There is also some danger from the use of the mining machinery, from projections along the sides of the galleries, and even in the elevator carriage itself. All in all the work is associated with a great deal of danger of various kinds.

Many of the miners employed are foreigners and negroes. The wages paid are usually good, but the work is very hard, and as a rule the miners do not work more than five or six hours a day. There are very few of them thrifty and many of them take so little care of their earnings that when a mine is shut down for any length of time, they suffer from actual want.

In the Iowa coal field, as in all the other coal fields of the Mississippi Valley region, there are many different beds of coal. Sometimes two or three workable beds are found one above the other; but more frequently there is but a single bed of sufficient depth to be profitably mined. In the southern portion of the state these beds extend over large areas; but farther north the beds are more local in character, and frequently a bed of coal which is four or five feet thick at the shaft, a half a mile or a mile away becomes too thin to be profitably mined, or runs out altogether. In such a region, it is a matter of much importance to prospect thoroughly and locate the coal bed accurately before sinking the shaft, in order to avoid a useless expenditure of money. The prospecting is done by drilling two-inch holes at intervals of about a thousand feet over the region where it is suspected coal will be found.

By studying the rocks and other strata of any region, scientists are able to tell whether it is likely coal will be found beneath, and are also able to say at about what depth it will be reached. While they are able to do this, yet they are seldom able to say whether the coal bed will be of sufficient thickness to be profitably mined or whether it will be of good enough quality to be worth taking out.



GRANITE QUARRY AT BARRE, VERMONT.

The granite block upon which the two men are standing is 50 feet long and 5 feet square. It plainly shows the drill holes on the sides, ends and tops. This block was separated from the ledge by drilling holes in a straight line a few inches apart, and splitting it off by driving wedges in all the holes at the same time. The drills, several of which are seen in the picture, are operated by compressed air.

VI.

GRANITE WORKS AND STONE-CUTTER'S SHOP.

True granite is composed of quartz, feldspar and mica. The quartz is usually grayish white or smoky. It is sometimes semi-transparent and always with a glassy appearance. The feldspar is either whitish or pinkish red. The mica is usually dark colored, frequently black. It is in scales and reflects light readily. These three minerals are not at all constant in quantity, sometimes one and sometimes another making up the larger part of the rock.

There are a number of granitic rocks usually classed as granites but which are not true granites. Syenite is one in which the quartz is largely absent, its place being taken by hornblende, a dark colored mineral. Quartzite is frequently, but wrongly, called a granite. It is made up entirely, or almost entirely, of quartz.

As regards appearance, granites are of two general kinds, red and gray. The difference in color is due to the color of the feldspar. One variety of feldspar is white, while there is another that is red. It is the white feldspar that makes the gray granite and the red feldspar that makes the red granite. The gray granites differ also very much among themselves from nearly a white to almost a black, the difference in shade being largely due to the quartz, a dark quartz of course making a dark granite and a white quartz a lighter granite. But the mica also plays some part in this, as some of the mica is almost black, which combined with very dark quartz would make an exceedingly dark granite. The red granites vary in shade for the same reason.

Granite is one of the most durable of all the rocks, that is, a good quality of granite is. The quality of granite varies much, on account of the varying proportions of the three minerals of which it is composed, and also depending upon the compactness or firmness with which the three minerals are cemented together. Some granites are so loosely cemented that when subjected to atmospheric conditions they readily disintegrate, the quartz becoming a coarse sand, the feldspar decomposing into clay and the scales of mica being distributed everywhere by wind and water.

But a firm, hard granite is almost indestructible and is the most widely used of all rocks for monumetnal and architectural purposes. It not only endures well, but is capable of taking a very high polish. It also presents a fine appearance when dressed. Granite is brought to the shop in large blocks. It is more or less rectangular and with the faces just as they came out of the quarry. The blocks are first roughly faced with hammer and chisel, and if they are to be finished as a rectangular

VIEW IN A STONE-CUTTER'S SHOP.

The blocks of stone are handled by the traveling crane overhead which is capable of carrying 20 tons. Much of the stone is dressed by chisels and hammers operated by compressed air.

blocks the angles and edges trued up. Then they are placed, sometimes a number of them together, on the large platform of the grinding machine. If there are several of the blocks and they are of different thicknesses they must be blocked up so as to bring the upper surfaces on a level. The cracks between the blocks are then closed up with some filling material and a dam usually made out of lumber built up three or four inches around the entire outer edge, a pan thus being formed on the top of the blocks which is made water-tight by a liberal use of plaster of Paris. Directly above on a swinging crane is a disk about three feet in diameter. The under side of this disk contains a number of soft iron rings between which is a filling of plaster of Paris. Water is then poured on the tops of the blocks and several pounds of very fine steel shot. The disk is lowered to the surface and set revolving at a very rapid speed. The crane is swung on a pivot which allows the disk to be constantly shifted from spot to spot over the whole surface. This grinding is kept up for five or six hours, nothing further being required except the occasional addition of water. When the disk is lifted, the dam removed, and the mud washed off, the surface is found to be ground down to a level. Sometimes the four faces and the top of a block are to be thus ground down, in which case more than two days are required to get the block into shape, as the same operation must be gone through with for each face.

The blocks are now ready to have any desired finish put upon their faces. If they are to be polished they are again put under the grinding machine and the same process gone through with as in grinding down their rough faces, excepting that a different disk is used and a polishing material employed instead of the steel shot. The polishing material is usually carborundum, an intensely hard substance manufactured by an electrical process especially for polishing purposes.

Much granite is used for architectural purposes and considerable of that employed in monumental work has a point finish or some other unpolished surface. These surfaces are put on with hammering tools of various design. Formerly the work was done largely by hand, but now in shops of any size, compressed air is used, and the work is much more rapidly accomplished. The beveling, lettering and other ornamental work, so much of which is required in shaping and finishing monuments, is also done in the same manner, a great variety of hammers, chisels and other shaping tools being used.

The quarrying of granite is a great industry. It is usually found in massive shape, although occasionally it is found sufficiently bedded to make the quarrying a much simpler process. In taking out the rock, much drilling and splitting is required in order that the blocks may be rectangular in shape. Little or no blasting can be done because broken up and irregular pieces are of little use for architectural and monumental purposes. The blocks are very heavy, the larger ones frequently weighing several tons. In the quarries they are handled by large swinging derricks, which lift the blocks from the place where they are loosened from the ledge, to the platform of the flat-cars which are run up into the quarry as far as possible. The larger shops are arranged for running the flat-cars into the building. Above the track there is a running crane. Heavy hanging chains are attached to the blocks and by a system of overhead tracks it is transported to any part of the shop. The handling thus becomes easy and expeditious.

There are granite quarries in nearly all mountainous parts of the United States. A fine quality of gray granite is taken out at Barre, Vermont, and both red and gray granite from other parts of the same state. In fact, every one of the New England states furnishes granite of good quality. The red granite from Quincy, Mass., is much noted. Both red and gray granite are now shipped from North Carolina and other states along the Appalachian system. Much comes from the Ozark Mountains in Missouri and from northern Wisconsin and from Minnesota. There are some noted quarries at St. Cloud and Montello, Wisconsin. The industry is being increasingly developed through the Rocky Mountain region and along the Pacific coast.

Formerly marble was much used for monuments. It is much easier worked than granite, not being nearly so hard to cut and taking a good degree of polish in a much shorter time. But it is not at all durable. A polished surface exposed to atmospheric conditions for ten years will have lost its fine finish, and in twenty years the polish will be completely destroyed. In old cemeteries are to be seen many marble slabs and monuments which have become so eroded and stained with time that it is difficult and sometimes impossible to make out the inscriptions. It breaks and chips very easily, too, and a shaft falling from its pedestal is very apt to be broken in two, or at least to have the corners knocked off and nicks chipped out of the edges. On account of it being so easily marred and weathering so rapidly, it is no longer used for monuments.

Among the granitic rocks much used are the quartzites and jaspers. Quartzite is a hard, compact, very fine sandstone, not differing in composition from an ordinary sandstone, but wholly differing in character on account of the metamorphic conditions to which it has been subjected. It does not take a fine polish, and as it usually breaks out in too small pieces to be used for monumental purposes, it is more largely used in building. It is not commonly dressed. Occasionally, however, it occurs of such a character that larger blocks may be taken out. In which case it is sometimes used for monumental purposes, largely with undressed surfaces.

Jasper is much on the order of quartzite, only of a much finer texture, breaking with a smooth surface like flint. It is usually of a dull red or brown color, although it may be of some other dark shade. Red is usually the color we associate with jasper, although the other colors almost as frequently occur.

APPENDIX

PICTURE STUDIES.

ROCKS.

Granite Domes of the Yosemite. Frontispiece.

The rock in each of these domes seems to be one solid mass. It does not lie in beds like that shown in the picture on page 12. The domes are shaped by the old glacier that entirely covered them, which shows that the igneous rock here did not harden evenly. The glacier ground away the softer parts and left the harder masses, rounding them into domes.

Questions:

What seems to indicate that each of these domes is a solid mass of rock? What shows that the igneous rock here did not harden evenly? What formed the domes and how did they come to have this shape?

A Limestone Bluff Along the Mississippi. Page 12.

Compare this picture with the frontispiece and note the difference in structure. Here, the different beds of rock show distinctly, indicating that the rock is sedimentary. The weathered face of the bluff on the right shows that the rock disintegrates readily and forms soil. The vertical fissures which show so plainly in the upper strata are the jointings common in limestone. Some of the layers are harder than others, as shown on the weathered face at the right.

Questions:

How does the rock differ from that shown in the frontispiece?

What shows that the rock is sedimentary? Does it weather easily? What makes you think so? What indications are there that the rock is mostly limestone? Find some of the layers that are harder than others.

Grand Canyon of the Colorado River. Page 13.

The picture on page 46 shows the character and thickness of the sedimentary rocks at the top. It should be studied in connection with this one. The lack of stratification shows that the walls of the "inner gorge" are composed of unsedimentary rock. The narrow, sharply V-shaped gorge shows that the rock is very hard. The upper gorge is very much wider, as well as deeper, and thus indicates that the sedimentary rock of which its walls are composed erodes easily.

Questions:

Compare the inner gorge with the upper gorge. Point out the sedimentary rock and the unsedimentary rock. Which disintegrates most readily? Which weathers into the smoother surface?